AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

INDO-PACIFIC FISHERIES COUNCIL

PROCEEDINGS

6TH SESSION
TOKYO
JAPAN
30 *September*—14 *October* 1955

SECTIONS II AND III

IPFC Secretariat, FAO Regional Office
for Asia and the Far East
Bangkok
1956

The full PROCEEDINGS of the 6th Session consist of three sections, of which the second, Technical Papers, and the third, Prawn Symposium Papers, are contained in this issue. Section I comprised the Report of Proceedings.

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1

ON THE FEEDING HABITS OF THE YOUNG LARVAE OF FRESHWATER AND MARINE FISHES

by

R. Sato*

INTRODUCTION

ring of some early larvae of fishes such as dace and catfish which have a rather larger ac and begin to feed at a comparatively late after hatching can be carried on successfully rtificial food. However, fishes such as smelt rp are difficult to rear with artificial food alone, ie same can be said for the marine pelagic of herring, pilchard, mackerel, plaice, cod thers. It is difficult, therefore, to know their g habits from rearing experiments using arti- ood alone. The alimentary tracts of over 75 per f the young larvae of the pond smelt caught in Kogawara in spring were empty, while those he other ponds where zooplanktonic organism h abundantly were found to be filled (Sato, It has been reported by Marshall *et al* that the proportion of feeding in herring was seldom large and sometimes as low r cent in the Clyde area of the coast of Scotland. facts may suggest that the amount of food sms at this critical period is a limiting factor early growth of the larvae and consequently nount of fry production. It seems, therefore, mportant to investigate the feeding habits of during their larval life to analyse the fluctua- fish population in natural waters.

FEEDING HABITS OF THE LARVAE OF POND SMELT AND OTHER FRESH-WATER FISHES

The pond smelt, *Hypomesus olidus* (Pallas), which is one of the most important land-locked fish in the inland waters of Japan, is caught commercially in such lakes as Abashiri, Kogawara, Hachirogata, Kasumiga-ura, Shinji and others. As it has high adaptability to various environmental conditions, it can be transplanted easily from one body of water to another. The pond smelt reaches the adult stage and spawns at the age of one year.

The yearly rate of production of fry in lakes, however, varies greatly and an investigation of the feeding habits of the larvae of the pond smelt was undertaken to discover the causes of such variations. Feeding experiments were carried on in tanks and also in experimental ponds to determine the food organisms which the larvae can eat. For the first experiment, one hundred larvae about 5 days old, that had begun to feed, were put into vessels of 25 litres capacity and fed with five kinds of unicellular organisms namely, non-coloured naked flagellates, *Chlamydomonas* sp., *Scenedesmus* sp., *Navicula* sp., and *Coscinodiscus* sp.

Although the naked flagellates and the *Chlamydomonas* were ingested by the larvae and could be

TABLE I

Percentage of frequency of the larvae of the pond smelt with various planktonic organisms in their gut. Results were obtained from the fish larvae in an experimental pond

tomach contents	Total length of the larvae (mm.)							
	6-7	7-8	8-9	9-11	11-13	13-15	15-18	18-21
macrocopa ..	0	0	0	29	0	0	0	0
a coregoni ..	0	10	63	43	67	70	69	70
nus bakeri ..	75	43	7	29	0	0	0	0
sp. ..	0	0	0	0	0	20	6	0
of Cyclops sp. ..	10	9	0	0	0	0	0	0
opsis sp. ..	0	0	14	0	0	0	0	0
ular algae ..	50	33	14	43	8	0	13	0

epartment of Fisheries, Faculty of Agriculture, Tohoku University, Sendai, Japan.

easily identified in the alimentary tract, the larvae showed no growth and the majority of them died in a few days. It is hence inferred that non-coloured naked flagellates and *Chlamydomonas* sp. are indigestible by the young larvae, even though they are devoured in considerable numbers.

A second experiment was undertaken in tanks of larger capacity, and similar results were obtained.

During this rearing experiment it was noted that the larvae are able to take a larger amount of food than might be expected. One of the larvae, 12 days old and 6.85 mm. in length was found swallowing a pine pollen having a diameter of 80μ which suggests that the larvae can utilize planktonic forms larger than the unicellular organisms. For the final experiment, therefore, the larvae were fed on zooplanktonic organisms which exceeded the unicellular algae in size.

Nearly ten thousand newly hatched larvae were put in an experimental pond of 40 square metres having a depth of 50 centimetres where unicellular algae and zooplanktonic organisms such as, rotifers, cladocerans and copepods were abundant. As a result, 420 larvae attained an average growth of 20.9 mm. after 47 days. From their stomach contents, the preference of larvae for food at the various stages of development could be determined. Young larvae from four to six days old and less than 8 mm. in length, took abundant rotifers, *Brachionus bakeri*, and a few nauplii of a copepod, *Cyclops* sp., besides small unicellular algae. Among them *Brachionus bakeri* seems to be most important as food for the young fish larvae. It was noticed under the microscope that these rotifers were well digested. After the larvae reached 8 mm. in length, they began to take a cladoceran, *Bosmina coregoni.* With progressive growth, another cladoceran, *Moina macrocopa*, and a copepod, *Cyclops* sp., besides *Bosmina coregoni* were also found in their alimentary tracts.

Such successive changes in the food of larvae may be due to their selectivity, probably related to the morphology of t rakers. The gill-rakers develop from b broad protrusions into very slender filamen together form a fine comblike structure at of age when the larva attains 30 mm. i The development of this type of gill-rake stage enables the fish to separate the zoop organisms from the minute unicellular o Such feeding habits of the fish larvae is s the results observed in Lake Kogawara (Sat Kokubo (1949) found in the same lake pond smelt of over 30 mm. in length t clusively zooplankton as food.

In a rearing experiment on larvae of (which belongs to the same systematic grou pond smelt) the Fishery Experimental S Tokyo (1936) reported that three days o ingested *Brachionus* sp. and nauplii of *Cy* The ingestion of *Brachionus* sp., by the larvae was also recognized by Matsui (1938 findings seem to support the conclusion pond smelt larvae take mainly zoopl organisms. Watanabe (1951) has report planktonic unicellular algae are not suitabl young larvae of the carp, though they ing abundantly. Zooplanktonic organisms, are known widely as favourite items of food f Therefore, in nursing the carp larvae in Ja regarded as necessary to provide water fleas *Moina macrocopa* and *Daphnia pulex* in ad

FEEDING HABITS OF THE PELA LARVAE OF MARINE FISHES

Larvae of the saury, *Cololabis saira*, smal 30 mm. in length were collected from the Japan and their stomach contents were e

TABLE II

Stomach contents of young pelagic larvae of marine fishes.

Fish	Stomach contents		Authors
	Unicellular algae	Zooplanktonic organisms	
Herring	*Chlamydomonas* sp. *Prorocentrum* sp.		Lebour, M.V. (1921)
Herring	Diatoms	Copepod nauplii	Marshall, S.M. Nicholls, A. G. & Orr, A. P. (1937)
Herring		*Rissoa sarsii*	Lebour, M. V. (1934)
Pilchard		Zooplankton	Scofield, E. C. (1934)
Plaice	Diatoms	Larvae of Mollusca	Lebour, M. V. (1918)
Mackerel	Coloured flagellate		Lebour, M. V. (1918)

found that the larvae had chiefly eaten zoo- nic organisms such as copepod nauplii with were mixed some other microorganisms that to be phytoplankton.

ellular algae, in fact, have frequently been in the stomachs of freshly caught pelagic It was shown by Gross (1937) that herring kept in the laboratory with cultures of *domonas* sp. would fill their guts with the lgae. This has been confirmed by Qasim in the case of larvae of shore fishes such as *s pholis*, *Centronotus gunnellus*, *Centronotus* and *Nerophis lumbriciformis*. However, the antities of flagellates and diatoms consumed noticeable effect upon the survival of fish lar- ereas the sustaining effect of some zooplank- rganisms had been recognized. Dannevig eared the larvae of herring and pilchard at the gen Seafish Hatchery by feeding the smaller ith oyster larvae and the larger ones with the of *Artemia salina*. Dannevig and Dannevig were successful in rearing the larvae of *ectes microcephalus* and *Solea solea* with the ems of food. Qasim (1955) found in his experiments that the larvae of *Blennius pholis* d for 64 days with *Artemia* nauplii. Accord- the experimental results mentioned above, ktonic organisms seem to be indispensable growth and survival of the larvae of pelagic

CONCLUSION

lanktonic organisms are preferable as items for the young larvae of certain freshwater fishes and the pelagic larvae of marine fishes, whereas unicellular algae are in most cases not digested by these larvae. The effect of the density of zooplanktonic organisms upon the survival of fish larvae will be studied, more precisely, in the future.

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2

FOOD AND FEEDING HABITS OF FRESHWATER FISHES OF MADRAS STATE, INDIA

by

M. D. Menon and P. I. Chacko*

INTRODUCTION

The study of the food and feeding habits of fish has received attention from various workers from different angles although the methodology adopted has varied considerably. Hynes (1950) and Pillay (1952) have given their reviews with critical assessment of the various methods employed. Rounsefell and Everhart (1953) have described the different methods used for collection of the material for detailed study of the food and feeding habits of fishes.

In 1942 the Indian Council of Agricultural Research sponsored a study of the bionomics of freshwater fishes under the Madras Rural Piscicultural Scheme and detailed studies on the food of the important food fishes and larvicidal fishes of the State were undertaken at the Freshwater Biological Research Station, Madras. An account is given in this paper of the food and feeding habits of the adolescents and adults of 59 species. The food and feeding habits of the larvae and postlarvae of these fishes will be published separately.

MATERIALS AND METHODS

The material for this study has been collected entirely from natural waters. The food analysis of the material from cultured waters has not been included in this paper, because it has been often noticed that under cultural conditions the food analysis showed a picture which was quite different from that of material collected from natural waters.

Thus, in the study of *Ambassis ranga*, Mrs. J. G. Abraham (unpublished) reported the food of this fish in the ponds of Chetpet fish farm as Copepods 77%, Cyprids 7% and Daphnids 16%, whereas Job (1941) detailing the food of *ranga* in the natural waters of Bengal has reported as follows : Mosquitoes (all sizes) 12%, other insects 16%, Copepods 46%, other crustaceans 25% and vegetable matter 1%.

In the study of *Tilapia mossambica* at the Freshwater Research Station, Madras it was noticed (unpublished reports) that the food analysis of over four hundred specimens collected from the natural ponds and tanks containing populations of *Gambusia affinis*, *Barbus stigma* and *Oryzias melastigma* showed only 0.1% of fish, whereas in an experimental tank kept devoid of water plants and filamentous algae but containing plenty of carp fry and *Gambusia*, *Tilapia* was moderately piscivorous. The
of 12 *Tilapia* from this experimental tank
the following percentages of the various
Unicellular algae 28%, Copepods 12%, Pr
7%, fish fry 47%, mud and sand 6%.

RESULTS

The results of volumetric analysis by g
food items in the guts of the fishes exam
given in Table I:

DISCUSSION

Mookerjee *et al* (1946) observed that "ta
account the percentage of various items of
fishes can be grouped under several heads.
speaking no fish is either strictly carnivo
herbivorous. But taking into considera
maximum percentage of food items we m
certain groups into such types ..
accordance with this view they classified
freshwater fishes of Bengal into six groups
though they did not give in detail the nom
of these groups, they suggested various com
of these groups for successful fish culture
differences in feeding habits.

Kesteven (1946) stated that although fi
be classified into herbivorous, carnivor
polyphagous, it is further necessary tha
these three major groups the fishes should
fied according to the major taxonomic grou
which they feed or according to the ecologic
tions under which they feed. Thus, th
taxonomic food groups under which the fi
be classified are diatom feeders, algae
crustacean feeders, molluscan feeders,
feeders, insect feeders, fish feeders, worm
etc.

On the ecological basis Ganapati and
(1950) considered several of the fishes of pis
importance as surface feeders, column fee
bottom feeders. Kesteven (1946) stated
is clearly important to determine within whi
of feeders a species stands and to discover
of species fed upon, extending the chain
phytoplankton is reached, for in this way, th
tions in the abundance of the food can be
. . . . " But such a study of plankton-feede

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* Department of Fisheries, Madras, India.

TABLE I

Percentage composition (volumetric) of the food groups in the gut contents of the freshwater fishes of Madras.

Name of Fish 2	No. of specimens examined 3	Unicellular algae 4	Filamentous algae 5	Higher plants 6	Protozoans 7	Copepods 8	Crustaceans 9	Insects 10	Fish 11	Molluscs 12	Worms 13	Mud and Sand 14	Amphibians 15
Plankton Feeders													
Barbus amphibius	260	62.0	18.0	—	—	12.0	1.0	5.0	—	—	—	2.0	—
B. aurelius	311	32.0	24.0	4.0	6.0	13.0	—	15.0	—	—	—	6.0	—
B. chola	250	68.0	12.0	—	—	12.0	4.0	—	—	—	—	4.0	—
B. dorsalis	210	37.5	15.0	—	6.0	11.6	8.3	20.0	—	—	1.6	—	—
B. dubius	136	29.1	24.1	—	1.0	12.5	2.0	17.2	—	12.1	—	2.0	—
B. filamentosus	175	28.0	22.0	—	—	24.0	8.0	10.0	—	—	—	8.0	—
B. sophore	250	44.0	24.0	—	—	16.0	2.0	10.0	—	—	—	4.0	—
B. ticto	270	34.0	25.0	—	—	20.0	5.0	10.0	—	—	—	8.0	—
Catla catla	1500	28.0	10.0	30.0	5.0	10.0	10.0	—	—	3.0	—	4.0	—
Cirrhina cirrhosa	360	52.0	19.0	—	8.0	14.0	7.0	—	—	—	—	—	—
Lebistes reticulatus	440	30.0	15.0	—	5.0	10.0	10.0	27.0	—	—	3.0	—	—
Labeo boga	110	31.0	22.0	—	8.0	15.0	12.0	—	—	—	—	4.0	—
Macropodus cupanus	320	35.0	20.0	—	5.0	—	20.0	15.0	—	—	—	5.0	—
Osteocheilus thomassi	176	60.0	5.0	—	10.0	20.0	—	—	—	5.0	—	—	—
Thynnicthys sandkhol	184	50.0	12.0	—	10.0	18.0	10.0	—	—	—	—	—	—
Ambassis nama	210	0.2	—	—	16.4	45.8	16.1	—	—	—	—	0.2	—
A. ranga	230	0.4	—	—	10.1	46.9	25.7	16.5	—	—	—	0.4	—
Barbus sarana	150	5.3	8.0	—	16.6	21.6	—	8.6	20.0	16.6	—	3.3	—
B. vittatus	145	32.0	18.0	—	—	34.0	1.0	8.0	—	—	—	7.0	—
Chela clupeoides	134	4.0	2.0	—	2.0	58.0	16.0	18.0	—	—	—	—	—
Insectivores													
Anabas scandens	185	—	2.0	13.0	—	—	10.5	40.5	14.0	19.0	—	1.0	—
Aplocheilus lineatus	413	22.0	—	—	9.0	11.0	—	58.0	—	—	—	—	—
Barilius bakeri	164	5.0	5.0	—	—	5.0	10.0	70.0	—	5.0	—	—	—
B. bendelisis	128	8.0	10.0	2.0	1.0	10.0	13.0	46.0	—	8.1	1.0	1.0	—
Chela argentea	27	15.0	10.0	—	5.0	17.0	3.0	55.0	—	—	—	—	—
C. bacala	5213	3.4	9.2	—	—	—	—	64.2	22.8	—	—	—	—
C. untrahi	385	4.0	3.0	—	3.0	22.0	2.0	66.0	—	—	—	—	—
Danio aequipinnatus	440	16.6	20.8	8.3	—	8.5	—	45.6	0.2	—	—	—	—
Etroplus maculatus	450	8.6	5.6	1.6	2.0	18.2	1.0	31.0	—	—	24.0	—	—
Gambusia affinis	610	25.0	15.0	—	—	10.0	5.0	45.0	—	—	—	—	—
Rasbora daniconius	400	25.0	7.0	12.0	—	—	—	51.0	—	—	5.0	—	—
Browsers or Bottom Feeders													
Barbus carnaticus	225	14.0	39.2	31.5	—	—	1.1	11.3	0.5	—	—	2.0	—
B. stigma	—	15.4	55.0	—	2.0	18.0	8.0	2.0	—	—	—	—	—
Cirrhina reba	423	18.0	54.0	6.0	10.0	9.0	—	3.0	—	—	—	—	—
Etroplus suratensis	576	28.0	44.0	2.0	5.0	4.0	3.0	2.5	0.5	—	1.0	10.0	—
abeo boggut	100	25.0	56.0	—	—	—	—	—	—	—	—	19.0	—
. calbasu	176	11.0	33.0	28.0	3.0	3.0	6.0	3.0	—	2.0	—	11.0	—
. fimbriatus	610	26.0	38.0	—	—	1.0	4.0	3.0	—	—	—	28.0	—
. kontius	214	21.0	16.0	19.0	—	4.0	3.0	9.0	—	—	6.0	22.0	—
epidocephalus thermalis	250	25.0	65.0	—	3.0	—	2.0	—	—	—	—	5.0	—
Nuria danrica	234	30.0	40.0	—	—	7.0	3.0	12.0	—	—	—	8.0	—
Ophicephalus punctatus	418	—	—	—	—	—	—	25.0	5.0	20.0	30.0	20.0	
angasius pangasius	175	—	1.6	10.7	—	—	2.3	18.2	31.8	35.4	—	—	—
Tilapia mossambica	433	21.0	52.0	12.0	0.5	5.1	1.0	—	0.1	—	—	6.0	—

S 2/2

TABLE I—*contd.*

Percentage composition (volumetric) of the food groups in the gut contents of the Freshwater fishes of Madras—(

Item	Name of Fish	No. of specimens examined	Unicellular algae	Filamentous algae	Higher plant	Protozoans	Copepods	Crustaceans	Insects	Fish	Molluscs	Worms	Mud and Sand
1	2	3	4	5	6	7	8	9	10	11	12	13	14
						Vegetable Feeders							
1	*Barbus curmuca*	232	10.0	23.0	38.0	6.0	3.0	9.0	5.0	—	—	6.0	—
2	*B. hexagonolepis*	375	7.1	5.3	45.1	1.2	—	2.6	26.1	0.6	7.0	0.2	5.
3	*Osphronemus goramy*	267	3.0	15.0	60.0	—	—	8.0	7.0	—	—	7.0	—
						Column Feeders							
1	*Barbus chrysopoma*	280	2.0	7.1	16.4	1.0	1.4	54.7	6.4	10.0	—	1.0	—
						Piscivores							
1	*Calichrous pabda*	187	—	30.0	—	—	2.0	—	—	68.0	—	—	—
2	*C. macrophthalmus*	231	—	—	—	—	—	1.8	28.0	69.0	—	—	—
3	*Glossogobius giuris*	311	—	—	2.0	—	—	—	11.0	78.0	9.0	—	—
4	*Gobius biocellatus*	172	—	4.1	—	—	36.6	8.3	51.0	—	—	—	—
5	*Mystus seenghala*	200	—	2.0	—	—	—	23.0	11.0	60.0	3.0	1.0	—
6	*Notopterus notopterus*	267	2.0	8.0	6.0	1.0	—	26.0	16.0	31.0	10.0	—	—
7	*Ophicephalus marulius*	250	—	—	—	—	—	—	—	55.0	—	5.0	20.
8	*O. striatus*	220	—	—	—	—	—	—	10.0	35.0	—	20.0	5.
9	*Saccobranchus fossilis*	413	—	—	—	15.0	—	16.0	22.0	42.0	15.0	—	—
10	*Silonia silonia*	126	—	1.0	—	—	—	18.0	12.0	47.0	17.0	—	5.
11	*Wallago attu*	211	—	—	—	—	—	14.0	7.0	78.0	1.0	—	—

be affected by the fact that "in general, plankton-feeders at least, ingest practically everything in the swarm upon which they are feeding and although when a swarm is virtually homogeneous, such feeding is fairly pure, mixed feeding is more usual" (*ibid*).

The classification of fishes into surface feeders, column feeders and bottom feeders, though sufficient for general observations, becomes unusable by itself when suggesting the combinations of fishes for fish cultural operations. Such classification will reveal broadly that both *Barbus chrysopoma* and *Wallago attu* are column feeders. But while the former feeds mostly on decapod crustacea, the latter is purely piscivorous in habits. A combined culture of these two, though apparently feasible from the above grouping, will not be productive.

The point is equally significant in the case of surface feeders. Thus in the utilisation of fish as larvicides for the biological control of mosquitoes, the surface feeding nature of the fish is utilised. It will be seen that both *Chela clupeoides* and *Gambusia affinis* are surface feeders. But since the former is predominantly a plankton (copepod) feeder and the latter is primarily insectivorous, *Gambusia*
will be more successful in the biological c
mosquitoes. It, therefore, becomes appar
in the study of food of fishes, it is often nec
classify the groupings with due reference
problems that are tackled. It would ofte
vantageous to make a combination of th
methods of grouping in a comparative stud
food and feeding habits of different genera an
of fishes.

Thus a workable classification for th
mentioned in the present study would be :

I. Surface feeders { Plankton feed
  Insectivores (I
II. Browsers or Bottom Feeders. i.e
  ing on filamentous algae, mollu
  worms.
III. Vegetable feeders. i.e., Feeding on
  plants.
IV. Column feeders. i.e., Feeding m
  larger crustacea like shrimps and
V. Piscivores.

A further classification of plankton feed
phytoplankton feeders and zooplankton fe
necessary when the suitability of a fish as cyc

examined. In some cases the utility of fish lication of several of the molluscs which are diate hosts for some of the helminth parasites ave to be assessed and in such cases it ssary that the grouping of 'browsers' has plit into various sub-groups according to the nic position of the organisms fed upon. The at are reported in this communication may, e, be grouped as follows (see also Table 1):

I—Surface Feeders :

r this group are included fishes that feed kton and insects :

lankton feeders : The typical plankton as determined from the percentage composi- their food, can again be split into (*a*) Phyto- n feeders and (*b*) Zooplankton feeders.

hytoplankton feeders : Fishes of this group nd to have in their guts food composed of ankton from about 28 to 68% by volume and ed of the following :

LOROPHYCEAE : Ankistrodesmus, losterium, Eudorina, Pediastrum, Scenedesmus. osmarium, Pandorina, Chroococcus, Coelas- rum, Crucigenia.

YXOPHYCEAE : Merismopedia, Spirulina, icrocystis.

ATOMS : Navicula, Nitzschia, Pinnularia, ynedra, Amphora, Fragillaria, Rhophalodia, urirella, Coconeis, Cymbella, Cyclotella, unotia, Gomphonema, Melosira, Tabellaria.

following fishes can be grouped under this

rbus chola, B. amphibius, B. sophore, B. ilamentosus, B. dubius, Labeo boga, Cirrhina irrhosa, Catla catla, Lebistes reticulatus, acropodus cupanus, Thynnichthys sandkhol, steocheilus thomassi.

oplankton feeders : A major percentage od of the fishes of this group is made up of ktonic organisms such as :

PEPODS : Cyclops spp., *Mesocyclops, seudodiaptomus* sp. and *Diaptomus* spp.

OTOZOANS : Arcella, Difflugia. Phacus, eridinium, Euglena.

TIFERS : Noteus, Diurella, Brachionus.

ADOCERANS : Diaphanosoma sp., *aphnia* spp., *Ceriodaphnia* sp., *Macrothrix* pp.

ishes falling under this group are *B. sarana, us, Chela clupeoides, Ambassis ranga* and *A.*

sectivorous fishes : Of the surface feeders, ishes show preferential feeding habits, taking mainly insects and their larvae in various stages of metamorphosis. These include *Chironomus*, Ephemeropteran larvae, Dipteran larvae, *Plea, Notonecta, Corixa, Ranatra*, Odonata larvae and *Cybister* and other water beetles. From an examination of the food, the following fishes can be classified as mainly insectivorous : *Chela bacala, C. untrahi, C. argentea, Barilius bakeri, B. bendelesis, Rasbora daniconius, Danio aequipinnatus, Gambusia affinis, Aplocheilus lineatus, Anabas scandens, Etroplus maculatus.*

Group II—Browsers or Bottom Feeders :

The fishes feeding on filamentous algae, molluscs and worms and those in whose stomachs sand grains are found in fair proportions, have been placed under this group. Generally, the filamentous algae are found in shallow areas or growing attached to rocks and such other anchorage at the margins, and the molluscs grow attached to those.

The main composition of the diet of the fishes of this group is as follows :

FILAMENTOUS ALGAE : Gleotrichia, Lyngbia, Oscillatoria, Oedogonium, Spirogyra, Nostoc, Ulothrix.

MOLLUSCS : Melanoides tuberculatus, Indoplanorbis exustus.

WORMS : Nais.

MUD AND SAND : Fishes under this head are *Barbus stigma, B. carnaticus, Labeo boggut, L. fimbriatus, L. calbasu, L. kontius, Tilapia mossambica, Cirrhina reba, Nuria danrica, Lepidocephalus thermalis, Etroplus suratensis, Pangasius pangasius* and *Ophicephalus punctatus.*

Group III—Vegetable Feeders :

As the grouping suggests, fishes classified under this category are found to have their diet composed mainly of the higher aquatic plants, dead leaves and seeds of land plants and other vegetable debris.

The following fishes can be placed under this group : *Barbus hexagonolepis, Barbus curmuca* and *Osphronemus goramy.*

Group IV—Column Feeders :

Under this are grouped those fishes that are found to feed on the faster moving and larger crustaceans like shrimps (*Caridina*).

Only *Barbus chrysopoma* has been found to feed mainly on the larger crustaceans and is classified as a typical column feeder.

Group V—Piscivores :

Lastly come the fish that are found to feed predominantly on fish. Both young and adolescent fish have been found in their gut contents. The piscivores have been observed to select positions of vantage in natural waters to capture fish that try to swim rapidly below dams and weirs.

The following fishes can be classified as typical piscivores :

Wallago attu, *Glossogobius giuris*, *Gobius biocellatus*, *Callichrous macrophthalmus*, *C. pabda*, *Mystus seenghala*, *Silonia silonia*, *Saccobranchus fossilis*. *Notopterus notopterus*, *Ophicephalus marulius* and *Ophicephalus striatus*.

APPLICATION OF FOOD AND FEEDING HABITS TO FISH CULTURE

One of the recognized problems of fish farm management is the combination of species that will produce the maximum yield of edible fish for each type of pond. The composition of such combinations will vary with the types of available food. ' So a pond should be stocked with surface feeders, column feeders and bottom feeders to get maximum production. As a general rule, it is advisable to stock a pond with 50% of fingerlings of surface feeders, 25% of column feeders and with 25% of bottom feeders ' (Ganapati and Chacko, 1950). These proportions are based on the fact that the region of biological productivity is confined to the region of photosynthesis and that the bottom region is the zone of biological reduction. Ganapati and Chacko (*ibid.*) have suggested various combinations with respect to the types of food available in various types of tanks.

Apart from food fish production, many of these fishes can be utilised from the point of view of public health. Many bodies of water emit a foul odour when having blooms of some algae, such as the blue green alga, *Microcystis*. *Cirrhina cirrhosa*, *Labeo boggut* and *Barbus dubius* are useful for combating these blooms. Very thick growths of *Hydrilla*, *Oscillatoria* and *Spirogyra* have been successfully cleared by *Tilapia mossambica*, *Labeo calbasu* and *Catla catla* in the Chetpet fish farm. The applicability of food and feeding habits of fishes becomes very apparent when their us
for control of water-borne diseases is ex
Thus *Gambusia affinis*, *Aplocheilus lineatus*,
daniconius and *Etroplus maculatus* have bee
very successfully for control of mosquito
and *Ambassis ranga*, *A. nama* and *Chela c*
are very good cyclopscidal fishes. Chac
Kuriyan (1949) have recorded the occurr
large numbers of molluscs in the stomachs
catla. The culture of this carp in rural wat
help the control of molluscs which
intermediary hosts of many of the helminth p

Most of the piscivores can very well be
culture in swamps and rock quarry pools ar
where net fishing is a problem and line fishin
is possible.

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3

TIVATION OF COMMON CARP IN RUNNING WATER IN WEST JAVA

by

K. F. Vaas[1] and M. Sachlan

he cultivation of *Cyprinus carpio* L. in sia is an old and well established practice, it is ng to note that new techniques are being even in recent times. The methods described present article, by which running water is used tivation of common carp in bamboo cages in ng and Garut, are deemed to be of interest following reasons. In the first place they strate how the Sundanese fish-farmer, al- well-versed in the immemorial traditional ls, is capable of devising and adapting new In the second place these methods, so far rried out on a limited scale, are suitable for on in other parts of Indonesia and abroad. ally, the results obtained during the investiga- this form of carp-culture might add some- to the scanty knowledge of polysaprobic, g, fresh-water environments in the tropics. ghout the work in the field the personnel of cal Extension Service for Inland Fisheries every assistance and the authors feel greatly d to them for their cooperation.

RP CULTURE IN RUNNING WATER IN BANDUNG CITY

eral description of the method.—About ar 1940 a new form of fish culture was ced in the river Tjibunut, a small branch river Tjikapundung, running through densely ed quarters of Bandung, the capital of West

Tjibunut divides into two branches, referred ne western and eastern branch, both used for lture. Both branches are about 4-5½ metres The depth of the water varies considerably, to the rainfall, the minimum being 30-40 he discharge capacity of one of the branches imated during the morning of a bright day t 200 *l.*/sec., but the flow is much more rapid and after heavy rainfall. Occasionally there y heavy spates (bandjir).

bottom of the river is covered with sand and vel, mixed with large stones, and the slope iverbed is 1 to 1½%. Houses and backyards run down to the banks of both branches closely, notably the eastern branch, where trees shade the water. The river is used as a sewer and convenience by a dense population and the water is heavily contaminated by kitchen-waste and human faeces.

In both branches bamboo cages are placed for carp culture. In the western branch 34 cages were counted in 1952 in a stretch of 40 metres, and in the eastern branch 198 within a few kilometres. Later on another 40 were added in the eastern branch further upstream. These cages are placed so closely together, that in many places one can walk over them. Undoubtedly they obstruct the flow of the river, which is a drain for rain water falling in the city, and the municipality of Bandung at one time seriously considered forbidding their use.

However, the wishes of the fishermen have prevailed up till now. The cages have a rectangular shape, measuring 1.5-3 m. in length, 90-150 cm. wide and 60-75 cm. high, and are constructed out of bamboo lath-work, each bamboo 2-3 cm. wide, with spaces in between of ½-1½ cm.

They are inserted at a slight angle into the bottom of the river, protruding 15-20 cm. out of the water level at its usual height. During flooding of the river they are completely immersed, but in the Tjibunut this situation only occurs occasionally. Fish culture is not adversely affected by these floods.

Most cages are anchored by means of strong wooden poles or iron bars. In the middle of the upper side is a small door, closed by a padlock. Strong material must be used because often pieces of wood or stones are hurled against the bamboo during floods and when the bamboo cracks fish will escape. The price for a reliable cage, locally known as 'karamba', amounted to Rps.[2] 250 in 1954. Such a cage will last for about two years.

The flow of the water deposits sand and gravel inside the 'karamba' and all sorts of refuse, such as leaves, twigs, paper etc. get stuck between the bamboos, tending to block up the slits. As a constant supply of water is essential, the cages must be cleaned every day. The fishermen open the

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aboratory of Inland Fisheries, Bogor, Indonesia.
lished with permission of the Head of the Laboratory for Inland Fisheries, Bogor, Indonesia.
ne Rps. = rupiah; 1 U.S. $ = 11.40 Rps. (official rate).

doors and remove the excess of sand and gravel with scoops.

The ‘ karamba ’ is usually stocked with common carp 8-12 cm. in length, grown in ponds from fry of 3-5 cm. Sometimes smaller fish of 5-8 cm. is stocked, both sizes at a rate of 200-400 fish per ‘ karamba ’. It is difficult to assess the total yield as the farmers are accustomed to remove the best-grown carps and either sell them alive in the market or stock them in separate karamba with large slits. According to information received locally, however, the yield amounts to 50-75 kg. in 2-3 months, sold for about Rps. 500.

Shortly after stocking there is usually some mortality among the carp and the fish appear to need some time to adapt themselves to the new way of living and feeding. Once accustomed, they may grow to a weight of 3½ kg. However the farmers usually do not keep the fish in the karamba for so long, in order to minimize the risk of losing their carp when the ‘ karamba ’ are damaged during floods.

Hardly any food is given except some rice-bran and stale bread. As will be shown in a later chapter this method relies mainly on a constant supply of natural food.

There are two opinions among the fishermen and the personnel of the Extension Service as to the origin of the method. As similar meth
common in Japan it is held that it was initi
the Japanese during the war, but others thi
it was developed among the numerous fish
living in the neighbourhood, who often st
fish to be sold in the market in small, round
baskets and who noted that carp left in the r
some time increased in weight.

Chemical analysis of the water.—
request the Laboratory of Technical Hyg
the Technical Faculty of Bandung carried o
chemical analysis of the water of the T
under the direction of Ir. J. G. Idema, to wh
authors are greatly indebted. The results are
in Table I.

These data indicate that the water is
sewage, on the one hand constantly contamin
kitchen-waste and human faeces—which fe
easily seen on the spot—and on the other ha
stage of active self-purification, owing to tl
temperature, the dilution with rain and the c
automatic aeration.

Our observations show that the oxygen
is maximal during the night and the early m
and decreases during day time, exactly opp
the diurnal fluctuations of stagnant water
heavy vegetation. During the night contam

TABLE I

Chemical analysis of the water of the Tjibunut.

	mg./l		m
Dry substances	368	Fe	
Mineral substances	286	Mn	
Colloidal silt	176	HCO_3	
Coarse silt	6	CO_2	
$KMnO_4$ used	46	SiO_2	
NH_4	6·5	Cl	
Proteid NH_3	2·0	PO_4	
NO_2	tr.	SO_4	
NO_3	8·0		
Ca	19		
Mg	tr.		

TABLE II

Diurnal fluctuations of some hydrochemical features of the water of the Tjibunut.

Time	Temperature		Water level	pH	Acidity (Methyl orange)	CO_2 mg./l	Oxygen Saturation		Secc visi c
	Air	Water					%	mg./l	
7 hrs.	21.9	22.5	High	7.4	1.36	8.0	53	4.6	
8.45	25.0	22.8	High	7.5	1.75	9.6	30	2.6	
13	29.9	28.9	Falling	7.4	1.40	8.0	32	2.5	
18	25.2	24.9	Falling	7.4	1.56	8.0	30	2.6	
22	23.9	23.7	Rising	7.5	1.56	6.4	45	4.0	

nan faeces is minimal and the activity of onsuming bacteria is minimal too, owing wer temperature. Between 6 and 7 a.m. ation will be maximal and, as the ure begins to rise during the day, the onsuming processes will increase. thesis is completely overshadowed by the oxygen consuming processes of mineralisation.

The Laboratory for Technical Hygiene also investigated the course of contamination during the day, by means of the permanganate-method and the decolouration of methylene blue.

Results are given in Table III.

TABLE III

Diurnal fluctuations in the contamination of the water of the Tjibunut.

Time	Decolouration of methylene blue in hours	Permanganate in mg./*l*
6 hrs.	—	28.4
7	53	34.8
8	45	46.7
9.30	44	46.4
10.30	52	38.8
11.30	55	35.7
13	62	30.0

lows from the above tables that the may be classified according to mann's classification, as belonging to the pe (Schmassmann 1951). If running Java is not contaminated, its oxygen tension ntly just below the saturation value, as was Buschkiel (1938).

organisms in the river and in the ba '.—The silt-laden, oxygen-deficient, unning water of low visibility is a most e environment for the development of and only some stray plankton, washed in where, was encountered. However on the of the 'karamba' the thread-bacterium *lus natans* Kutz. was growing in thick many threads were floating in the water. nd in bulk on the 'karamba' were the : *Zoogloea ramigera* Itzig. and *Beggiatoa* uch.), the Cyanophyceae: *Oscillatoria* and *Lyngbya* and sessile Ciliata such as *Vorticella microstoma* Ehr., *Opercularia* sp., *Colpidium colpoda* Stein and *Carchesium polypidium* (Lach.) (Kent) L., together with other, free living Ciliata, *Rotifer neptinius* Ehr. and *Glossosiphonia heteroclita* (L).

Among the threads of *Sphaerotilus* and the blue-green algae, among the masses of leaves and grass strained out of the water, and notably in the sand and silt on the bottom and along the shores, enormous quantities of Oligochaeta were found, mainly *Limnodrilus hoffmeisteri* Clap. with a few *Branchiura sowerbyi* Bedd.[1]

Besides worms, red Tendipedidae are very frequent, mainly larvae of the *plumosus*-type, usually 1–1½ cm. in length, with long, curled, ventral blood-gills, and distinct lateral gills.

Table IV gives an idea about the density of these organisms.

TABLE IV

Tendipedide larvae and Oligochaeta in 2 dm.^{2} bottom of the Tjibunut.

	Number	Total weight in mg.	Average weight per head (mg.)
ae	48	152	3.2
	281	551	2
Total		703	

---

interesting worm is very common in shallow waters in west Java, although the only reference in the literature by Stephensen (1923) who refers to Bovien.

A few green thread-algae, such as *Cladophora* and *Spirogyra* were found on the cages and, on the stones in the riverbed, some Diatoms (*Surirella*) and some Protozoa (*Arcella discoides* Ehr.).

In the western branch of the Tjibunut, where contamination is less heavy and the water is also less shaded, more red Tendipedidae and less Oliogochaeta are encountered and more plankton is washed in from neighbouring fish ponds, consisting of *Raphidum* and *Rotatoria*. The same holds for the up-stream section of the eastern branch.

If we try to classify this association with the aid of the Kolkwitz-Marsson system as revi Liebmann (1951), we find certain affinities to sewage of the polysaprobic group, but also mesaprobic group, because chlorophyl-bearin are not entirely absent although forming minority.

Gut-contents of the carp.—The guts of 201.5 gm. in weight, 24.5 cm. long and 5 old, were cut into sections of 3 cm. The c of each section were studied under the mic with the following results (Table V).

TABLE V

Gut contents of a large carp grown in a karamba.

Section of guts cm.	*Tendipedidae* larvae	*Tendipedidae* pupae	*Oligochaeta*	*Nematoda*	Veget rema
0-3	—	—	—	—	—
3-6	44	—	9	—	+
6-9	30	—	13	—	—
9-12	24	1	11	—	+
12-15	—	—	—	1	X
15-18	—	—	—	1	X
18-21	17	1	2	—	+
21-24	16	1	5	—	+
24-27	8	1	1	—	+
27-30	10	1	1	—	+
30-33	22	1	1	—	+
33-36	19	1	2	—	+
36-39	17	3	5	—	+
42-45	7	1	2	—	+
45-48	29	1	1	—	+
48-52	12	—	1	—	—
Total ..	270	11	58	2	+

The *Tendipedidae* larvae could easily be recognised by the chitinous heads, the pupae by the trachea, the worms by the rows of chaetae still *in situ* on the completely emptied and transparent skins.

As the *Oligochaeta* are always severely crushed and often cut into small parts by the pharyngeal teeth of the carp, the counting must remain an estimation. Still it is striking to note the differen of the numbers of worms and larvae inside a side the guts, as shown by a comparison numbers given in this table with those of The *Nematodes* were obviously ingested alon the plant parts.

Five more carps, grown in these cage investigated, with similar results (Table VI

TABLE VI

Gut contents of 6 carp grown in karambas

—	5 carp, weight 82-84 gm., length 17·5-18 cm., age 3½ months, 1 month in karamba					1 carp, w 29·5 gm., 12 cm., a months, 1 in karam
	I	II	III	IV	V	
Tendipedidae larvae	33	42	29	42	32	7
Tendipedidae pupae	4	14	6	5	4	4
Oligochaeta	4	31	11	—	12	208
Nematodes	—	1	—	1	—	—
Plant parts	xxx	xxx	x	xxx	xxx	x

(12 cm. 29.5 gm.) was exceptional as here ber of worms exceeded that of the insect-

sh mentioned above were collected in the ranch of the Tjibunut. Table VII gives the results of an examination of a carp from a karamba of the western branch, comparable as regards length and weight, with the one from the eastern branch mentioned in Table V. This fish was one month older.

TABLE VII

t-contents of a Common Carp, grown in a karamba in the western branch of the Tjibunut. Weight 204 gm., length 24.9 cm., age 6 months, 4 months in the karamba.

Section of guts cm.	*Tendipedide* larvae	*Tendipedide* pupae	*Oligochaeta*	Vegetable remains
0-3	1		1	xx
3-6	2	2	4	xx
6-9				xxx
9-12				xxx
12-15		1		xxx
15-18	2	2	1	xxx
18-21	2			xx
21-24		1		xx
24-27		1		xx
27-30		2	1	xx
30-33	4		1	xx
33-36	3		1	xx
36-39				xx
39-41				xx
Total	14	9	9	

guts of this carp more vegetable remains insect-larvae and worms were found. imals were also less frequent on the bottom. rition of carp from karambas was compared of carps grown in neighbouring rice fields ing the gut-contents of 7 carp bought at et in the early morning. These fish were caught shortly before and the guts were well filled. Results are shown in Table VIII. Comparing these results with those of the foregoing table, it will be seen that the diet of the carp in rice fields is more varied, comprising Copepods and snails, both absent in the Tjibunut. Worms and Tendipedide also constitute important items. In Central European

TABLE VIII

Gut-contents of 7 carp grown in paddy-fields. Weight 49-100 gm., length 15-20 cm., age 3-5 months

	I	II	III	IV	V	VI	VII
lae d pupae ..	xxx	xx	xxx	xxx	xx	xx	xx
a ..	x		x				
..	xxx	xxx	xxx	x	xx	x	xxx
of snails ..	xxx	xx		x			xx
eae ..	x	x					
..	x	x					
remains ..	xxx	x	xx	x	x	x	x

literature on the natural food of the common carp both groups of organisms are always mentioned as very suitable and frequently ingested food.

Morphometry of the carp.—The fish farmers of Tjibunut hold that their carp differ from those grown in paddy fields and ponds in so far that they are higher, the heads are smaller and lower, the weight at similar length is higher and the flesh is fatter.

An attempt was made to check these st by measuring 60 fish from the cages and 2 at the market. The length of the head was m from the tip of the snout to the end of the op and its height along a line passing through th of the eye perpendicular to the longitudi of the fish. The authors gratefully ackn the assistance of the Statistical Section of the Agricultural Research Station, Bogor, in the tion of the results.

TABLE IX

Difference in proportion of the body of carp grown in karamba's to carp grown in paddy fields.

—	Ratio Length/Height		Ratio Body Length/Length head		Ratio Body Length/Heigh	
	Karamba	Paddy field	Karamba	Paddy field	Karamba	Padd
Number of fish measured	60	23	60	23	50	
Average	3.49±0.03	3.79±0.06	4.12±0.03	4.02±0.04	7.33±0.10	7.0
Difference	0.30±0.07		0.10±0.05		0.28±0.12	
Reliability of difference	Reliable		Practically reliable		Practically relial	

Even our limited material was able to indicate that the farmers are right in their statement and that characteristic differences in the outward appearance of the carp exist. As only a small number could be weighed, we were not in a position to check the statement concerning the heavier weight of fishes of equal length. However, the percentages of fat in both groups could be determine Laboratory of Animal Nutrition of the V Faculty of the University of Indonesia a and we thank the Head of this Laborato Dr. P. Schoorl, for his assistance. The are given in Table X.

TABLE X

Chemical analysis of 4 fishes from 'karamba' and ricefields.

Origin of carp	Length cm.	Weight gm.	Dry weight gm.	(entire fish) Water %	(entire fish) Protein %	Ashes %
Ricefield I	20	113	24	79.0	15.7	2.9
Ricefield II	19.5	128	27	79.0	16.2	3.3
Karamba I	27	188	46	75.5	15.8	3.0
Karamba II	20	173	41	76.3	16.3	3.1

ough only a slight difference is seen between er substances, the percentage of fat of the om the 'karamba' is conspicuously higher.

wth of the carp.—By courtesy of the Inland Fisheries Extension Service of the Regency of Bandung we were able to follow the growth of fishes in two 'karamba', operated by this agency and the results are given in Table XI.

TABLE XI

Growth of carp in a 'karamba' in the R. Tjibunut

in ks	Stocked				Cropped			
	Number of fish	Total weight kg.	Average weight gm.	Average length cm.	Number of fish	Total weight kg.	Average weight gm.	Average length cm.
	150	11	73.4	18	150	9.0	60	15
	120	10	83.5	19	48	3.5	73	16
	106	10.5	99.0	19.5	46	3.75	81.5	17.25
	106	11	104.0	20	42	4.0	93.5	17.75
	106	11.7	110.0	21	42	4.25	101.0	18.25
	106	12.75	130.0	21.5	42	5.0	119.0	18.75
	106	16.5	551.6	22	40	5.5	137.5	19.25
	94	16.5	177.6	22.5	40	5.5	137.5	19.5
	40	8	200.0	24	40	7.5	187.5	20

ill be seen that in both cases the results were n successful from a practical point of view. , owing to the extremely heavy losses, far than those usually suffered by the farmers, ld was negative in both cases. As no dead re found throughout the experiment, escape t can be the only cause. The fish farmers ear their 'karamba' are able to take better them and, as was stated above, usually do not cultivation over a very long time. However, ring the increase in average weight, it will that growth is rapid and also that the velocity vth is independent of the number of fishes , which is not the case in ponds. Here, a constant supply of food whereas the limited ion of food by a pond is greatly influenced number of fishes feeding on it. As the row their demands increase and the rate of of fish in a pond must gradually decrease the pond is understocked. However, in e we find an ever-increasing rate of growth dent of any change in the number of fish. npossible to compare the yield of carp in cages with that in ponds, as in the latter case the space factor is all important, which factor does not come into play at all in a karamba.

CARP CULTURE IN RUNNING WATER NEAR GARUT

(a) Experiments in the River Tjimaragas.—The success of the above form of carp culture caused the Extensive Service for Inland Fisheries in the Province of West Java to look for possibilities elsewhere, and as a result, a large 'karamba' measuring 3.5 × 1.2 × 0.9 m. was placed in the river Tjimaragas, a small river near the city of Garut, situated in the south-eastern part of West Java. The water of this river was yellow owing to a great deal of lateritic silt, and not so polluted as the Tjibunut water. This river does not differ from any other small river in the area.

No samples could be taken in this case, but fairly good results were obtained in the three experiments carried out in this karamba, as shown in Table XII.

TABLE XII

Results of three experiments of carp culture in a karamba in R. Tjimaragas, near Garut.

xp.	Stocked	Cropped	Time	Increase in weight
	200 carp 12-18 cm. in length Total weight 15 kg.	200 carp 22-26 cm. in length Total weight 22 kg.	1 month	6 kg.
	322 carp Total weight 20 kg.	322 carp Total weight 26.4 kg.	32 days	6.4 kg.
	33 carp Total weight 50 kg.	33 carp Total weight 63.5 kg.	1 month	13.5 kg.

Without being in a position to state what the fish have been feeding on and under what conditions they were living, it might be concluded that good growth took place without any loss, with a better result in the case of the larger carp.

(b) Popular efforts with carp culture in running water.—As a result of propaganda by the Extension Service, the people of Garut took up this form of fish culture in the River Tjiwalen. In August, 1954, 88 karambas were counted. The Tjiwalen is another ordinary, small river, 6-7 m. wide and not very polluted (because it does not traverse the city) and with a sandy bottom. In the water visibility of only 18 cm. was measured and hardly any vegetation was seen. As this river is far less used as a sewer than the Tjibunut, the large amount of rubbish such as leaves, grass, paper, kitchen-waste etc. found here was absent in the Tjiwalen.

The water was analysed at the Laboratory of Technical Hygiene at Bandung, by courtesy of Ir. Ang Goan Hoat, to whom the authors are greatly indebted. The results are shown in Table XIII.

TABLE XIII

Analysis of the water of the Tjiwalen. Between brackets are figures from the Tjibunut taken from Table I for comparison

	mg./*l*.	
Dry substances	239	(368)
Mineral substances	225	(286)
Colloidal silt	16.4	(176)
$KMnO_4$ used	27.5	(46)
NH_4	tr.	(6.5)
Proteid NH_3	0.1	(2)
NO_2	—	(tr.)
NO_3	0.18	(8)
Ca	20	(19)
Mg	11	(tr.)
Fe	1.3	(0.2)
Mn	tr.	(tr.)
HCO_3	129	(119)
CO_2	12	(9.2)
SiO_2	60	(114)
SO_4	tr.	(—)
Cl	6	(28)

The table shows a great difference between the two rivers, notably far less pollution, conspicuous from the lower figures for colloidal silt, $KMnO_4$, Cl, proteid ammonia, No_3 and No_2. The amount of calcium is fairly similar, but the Tjiwalen contains more magnesium and less silica. The pH of the water fluctuated from 7.6 at midnight to 7.3 during the day.

The methyl orange acidity fluctuated slightly around the figure 2.25. As the water contains a fair amount of Mg-ions its buffer capacity exceeds that caused by calcium alone. An approximate B.O.D. value was established in the field by leaving undiluted water for 29 hours overnight. A value of 4.95 mg./*l* O_2 was observed. The water
its heat practically the whole night, warm
in the morning towards a maximum at 3
in the afternoon. Dissolved oxygen never
saturation, fluctuating between a value of
(5.52 mg.) at 6 a.m., and 85.3% (7.46
6 p.m.

It follows from these figures, as well as fr
chemical analysis, that a certain amount of p
takes place, and also that, as in Bandung,
synthesis is unimportant. The reason is th
Here too, hardly any vegetation, micro- as
macro-, can develop in the rapidly running,
silt-laden water, and here too pollution with
faeces takes place. The fishfarmers pu
constructed a number of conveniences n
cages and the supply of human faeces is consi
Here again, this pollution takes place mainly
early morning and late afternoon and is almo
existent at night. The fluctuations in the
of polluting matter combined with those
activity of oxygen-consuming bacteria, ov
fluctuating temperature, explain the course
dissolved oxygen and permanganate consu
during 24 hours, as shown in the figures.
lag of about 3 hours, the graph for dissolved
is seen to follow a course opposite to the on
permanganate.

Technique of culture.—The 'karamba
in the Tjiwalen are somewhat bigger th
Bandung ones. Those used to stock about
of fish measure 3 × 1.2 × 0.9 metres and bigg
measuring 3.5-5 m. in length are used for
about 35 kg. The latter are 1.2 m. wide and
high. In order to facilitate the cleaning of
a small structure is made on top of the upp
and the upper part of the wall facing the
slopes backward, making the 'karamba
streamlined. The 'karamba' are planted
with about 12½ cm. inserted in the botto
in the Tjibunut the 'karamba' are not often
covered with water and they are seen to b
more sturdy than in Bandung, where sometim
escapes of carp occur.

Some farmers feed the carp with a mi
bran, cooked rice and stale bread twice
Sometimes the fodder is given in a gasoline
a pierced bottom. Other farmers do not fee
and rely on the supply of human faeces. T
are often seen to feed voraciously on this

For stocking purposes fish 16-18 or 20
in length, obtained from ricefields are used,
of 20 kg. total weight in the smaller and
in the bigger cages. As in Bandung th
growing carp are removed and sold after on
and the rest stay on, supplemented by an a
stocking of small fish.

ie case, where additional food was added as ed above, 220 carp weighing 100 gm. each, ocked and cropped after one month with a eight of 34.4 kg., so the increase amounted to . in one month. It is held by the farmers that of about Rp. 90 can be obtained every month single ‘karamba’, for which 250 rupiahs be paid when bought new. As this method only about nine months before our investiga- re are not able to estimate the average life aramba’, although an estimate of two years ot seem too long. With this assumption profit would amount to about 80 rupiah 8 kg. of fish) a month. The yield is much han that obtained in the Tjibunut.

ral food production in the river.—The jiwalen does not produce much natural food carp, owing to its unfertile, sandy bottom large amount of silt in the water. The t scouring of the sand and silt against the bamboo is probably one of the reasons for the scanty growth of epiphytic and epizoic organisms on them.

In the water itself a few diatoms and crustaceans were found, mainly washed in from other habitats. On the bamboos and in the sand on the bottom within the cages, a few *Nais raviensis*, *Limnodrilus hoffmeisteri* and *Branchiodrilus hortensis* Steph. were found, together with some Tendipedides such as *Tendipes plumosus*, *Tanytarsus* and *Paratanytarsus* larvae, all these organisms occurring in far smaller numbers than in the Tjibunut, where the *Tanytarsus* larvae are totally absent owing to their larger oxygen requirement.

Food of the carp.—It will be evident from what has been stated in the foregoing chapter, that the natural food production of the river is relatively unimportant as a source of food for the fish. This was borne out by a study of the gut contents of five carps. Some data on these fish are summarized in Table XIV.

TABLE XIV

Data on five carps used for study of intestinal contents

carp	Length in cm.	Length of guts in cm.	Contents of guts in cc.	Time in karamba	Additional food
	18	27.5	8.7	1 month	nil
	18	30	9.9	1 month	do
	18	27.5	9.9	1 month	do
	31	49.6	14.1	2 weeks	do
	20	33	7.6	—	bran, rice, bread

e were conveniences near all three cages and in all of them had access to a constant supply in faeces.

contents of all the guts proved to consist of human faeces, as could be concluded from nt debris and starch grains encountered in ligested condition even in the first part of s, and from the large number of eggs of internal parasitic worms of man: *Ascaris lumbricoides*, *Ancylostoma duodenale* and *Trichocephalus dispar*. In the guts of No. V, remains of bran and bread could be discerned. Natural food forming a minor part of the total contents consisted of Crustaceans, Tendipedidae, other aquatic insect-larvae and thread algae, the latter only partly digested. The data are summarized in Table XV.

TABLE XV

Gut contents of five carps from three karambas in Tjiwalen.

	I	II	III	IV	V
ans :					
a	4	..	..	..	3
s	6	..	4	..	3
oda	..	..	4	..	..
edide Larvae	4	10	6	..	5
aquatic insect-larvae	8	1	4	..	2
l algae	..	..	..	13	many
remains	present	present	present	present	many
	..	..	..	..	present
	..	..	..	..	present
arasitic worms :					
lumbricoides L.	1,991	718	2,417	2,645	499
stoma duodenale Dub.	15	..	11	..	..
ephalus dispar Rud.	65	8	60	118	27

DISCUSSION

The use of running water for fish culture is fairly common in the Indo-Pacific area. In Japan, carp are grown in small ponds, heavily fed when still small with Oligochaeta and Tendipedidae, collected from sewers and shallow muddy water-courses, and later with cooked cereals and silk-worm pupae (Japanese Fisheries Agency, 1952).

In Cambodia, *Pangasius* fry are caught in the river and grown in floating bamboo cages not touching the bottom. A mixture of cooked vegetables and crushed, small fish is used as food. (Lafont & Saveun, 1951).

Both these methods show that natural food is unimportant, and that the water has only to provide the fish with an aerated environment. Because the water is flowing a large number of fish can be stocked in a small space without danger of suffocation.

The Sudanese methods described differ in that human faeces form the main source of food, in Bandung almost entirely indirectly via the Oligochaeta and Tendipedidae and in Garut almost entirely directly. In both cases the food chains involved are extremely short ones and both methods must be deemed very economical.

It must be admitted that the carp grown in this way may become a source of infection or infestation for the consumer, notably by intestinal worm parasites, as indicated by the large number of eggs in the guts, but also by various bacterial diseases. However, when the intestinal tract is removed and the flesh thoroughly washed and well cooked, no danger will ensue. It is well known that the Chinese consumer has been eating carp feeding on human faeces for centuries without being the worse for it.

In many countries the consumers object to eating fish fed in this way for various reasons and the potential feeding capacities of sewage ar
wasted or used in agriculture or hort
When this is not the case, both methods d
above might be used to advantage, provided

(1) a constant supply of running wa be used. If highly polluted, t of flow should be high becaus oxygen is needed.

(2) a source of fry or fingerlings to s cages is readily available.

(3) in the case of only slightly pollute a supply of cheap food, such as r can be used.

(4) eventual floods in the river are severe and too prolonged.

(5) the fish farmers are in a position t their cages daily.

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4

RODUCTION OF *TILAPIA MOSSAMBICA* IN AN EXPERIMENTAL POND AT BANGKHEN, THAILAND

by

U. Pongsuwana[1]

INTRODUCTION

xperiment was conducted between February and February 22, 1954 at the Bangkhen s Experimental Station, Bangkok, Thailand, rmine the productivity of a pond under conditions and the economic aspects of rural ture in Thailand. The results were recorded n Indrambarya, S. W. Ling, and Ariya unka (in Ms.)

total weight of fish produced over the 382 the experiment was equivalent to 17.8 ons per hectare per year, or about seven tons . Because of the skepticism which has often pressed by practical fish culturists operating emperate zone regarding production figures ical waters, and the desire of the Thai s Department that the results of its experi- hould not err on the high side, a further ation was carried out by the present author and 1955 and a comparison of the two ex- ts is given below, insofar as the available mit.

ond utilized was about five years old, having eviously used for culturing *Pangasius* and Carps, with an area of approximately 2,000 metres, an average depth of 1.5 metres, steeply sloping sides and a flat bottom. The soil is of fertile muddy clay and the pH of the water about 7.0.

In both cases, the pond was drained immediately prior to the experiment, cleared of predators and other undesirable species by means of derris root and fertilized with farm manure, after which 200 spawning pairs of *Tilapia mossambica* were introduced. Pig raising was conducted in connection with both experiments and chicken raising in connection with the first experiment only, the excrements in both cases being washed down into the pond.

FIRST EXPERIMENT

The pond was stocked on February 5, 1953 with 200 spawning pairs of *T. mossambica* with an average length of 14.6 cm. and an average weight of 69.0 gm. One *Ipomea* bush was planted in the water on each of the four sides. The experiment terminated with the final harvesting on February 22, 1954, 382 days later.

Unfortunately, no breakdown of the size classes harvested is available, other than by fry (3-5 cm.), fingerlings (6-9 cm.), adult Tilapia (average weight 150 gm.) and miscellaneous fish, as shown in Table I.

TABLE I

Harvest from the first experiment (1953-54)

	Tilapia Fry		Tilapia Fingerlings		Adult Tilapia		Miscellaneous Fish	
	No.	Weight kg.	No.	No. kg.	No.	Weight kg.	No.	Weight kg.
y 1953 ..	107,488	200	5,638	150	..	..	..	..
December 1953	..	..	..	..	3,047	457	..	..
1954 ..	..	..	..	..	18,775	2,810	362	110
					21,822	3,267	..	..
nal stock ..	..	..	..	..	400	27	..	..
	107,488	200	5,638	150	21,422	3,240	362	110

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eries Department, Bangkok, Thailand.

The sale value of the total crop was as follows :

Tilapia fry	200	kg. at	5	Baht* per kg.	Baht	1,00
Tilapia fingerlings	150	,,	5	,, ,,	,,	75
Adult Tilapia	3,247	,,	4	,, ,,	,,	13,00
Miscellaneous fish	110	,,	5	,, ,,	,,	55
	3,707					15,30

The fish were fed daily. Some of the rice bran was administered raw and was readily accepted. The broken rice was cooked together with the remainder of the rice bran and administered pieces. The weight and cost of the foo were as follows :

	Weight kg.	Cost Baht
Peanut cake	443	665
Rice bran	3,809	1,905
Broken rice	1,000	750
	5,252	3,320

The balance of expenditure and income was therefore as follows :

Interest on capital investment and depreciation of gear	Baht 1
†Cost of labour (1 full-time worker) 13 months at Baht 400 per month	5
Cost of fish food as above	3
Cost of fuel for cooking	
Cost of derris root and fertilizer	
Cost of pumping	
	9
Income from sale of crop, as above	15
Net profit	5

It is to be noted that a rather large number of miscellaneous fish entered the pond, probably overland, during the rainy season. The predators among them appear to have eaten up all the Tilapia fry produced after the crop taken in April and May. The effect of this was to permit better growth of the adult population, which averaged 150 gm. in weight when the pond was finally drained, and an income from the sale of miscellaneous fish of 550 Baht.

The total production from the pond was 3,707 kg. of fish of all sizes and species, which is equivalent to about 17.8 metric tons per hectare per year, or about 7 tons per acre per year.

SECOND EXPERIMENT

In order to check that the above high production figure was not due to error, a second experiment was carried out with a somewhat more precise breakdown of the crop into length frequencies for better comparison with the third and subsequent experiments.

The pond was treated with derris for a period of seven days and after scattering with farmyard manure (1,680 kg.), was flooded to a dept cm. for a further seven days, when the p completely filled. Two *Ipomea* bushes compost piles of dry grass (about 240 k placed in the corners of the pond. Pig ra started on August 11, 1954 and in this case was set over the water on stilts.

Stocking took place on March 16, 1954 pairs of spawning Tilapia with an average l 15.8 cm. and a total weight of 29.4 kg. The ment lasted until May 6, 1955 or 416 days.

The demand for Tilapia fry having d considerably owing to the large produc private culturists in their own ponds, it was to observe the effect of leaving all the fry in th except for the removal on July 9 of 2,000 fingerlings with an average length of 3.5 c total weight of 2.3 kg. This was done on the tion that the number of predatory fish ente pond during the rainy season would be co with that encountered in the first experimen would have resulted in the natural thinnin juveniles and a correspondingly larger inco miscellaneous fish to compensate for the r in the sale of fry to the public.

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*US $1 = 22 Baht approx.

†In most cases this work can be carried out by members of the family.

ll be seen from Table II, the expected invasion dators did not materialize. It should be ed here that some of these, and especially *Clarias*, and the snake head, *Ophicephalus* are air-breathers and are capable of travelling considerable distances overland.

TABLE II

Composition of miscellaneous fish crop in the two experiments.

		First experiment		Second experiment	
		No.	Weight kg.	No.	Weight kg.
halus	spp.	165	80.0	15	10.1
	,, ...	48	13.0	9	11.3
tris	,, ...	35	3.0	24	3.7
rus	,, ...	38	4.6	3	0.8
	,, ...	30	7.0	—	—
terus	,, ...	46	2.4	2	0.1
		362	110.0	53	26.0

the exception of 2,000 fry and fingerlings d in July 1954 no cropping took place until l draining of the pond on May 6, 1955. The total yield, broken down into length frequencies, was as follows :

TABLE III

Fish harvested in second experiment (1954-55)

	No.	Total Weight kg.	Average Weight gm.
length 1″ - 2″	490	3.1	6.1
,, 2″ - 3″	9,272	99.7	10.8
,, 3″ - 4″	46,593	725.9	15.6
,, 4″ - 5″	36,730	1,066.7	29.0
,, 5″ - 6″	12,903	661.4	51.3
,, 6″ - 7″	3,937	332.3	84.1
,, 7″ - 8″	1,672	213.0	127.5
,, 8″ - 9″	408	69.65	170.7
,, 9″ - 10″	112	22.65	202.2
	112,117	3,194.4	28.5
neous Fish	53	26	491
	112,170	3,220.4	
ginal stock	400	29.4	
d	111,770	3,191	
of days..................................	416		
r year of 365 days..................................		2,800	
r hectare per year..................................		14,000	
r acre per year..................................		5,600	

frequency of each length class, the total of each class and the curve showing rage weight per fish in each class have been l in graph form in Fig. 1, so that the third bsequent experiments may be effectively towards obtaining even more satisfactory the object being to achieve right-handed skewness in the weight of the length classes rather than left-handed (and hence an improvement in the modal class). In the present experiment, the greatest weight yield was calculated to have consisted of fish grouped around the mode* of 4.46″ while the modal frequency occurred at a round the length of 3.79″.

$$= l_1 \frac{+\Delta_1}{\Delta_1 + \Delta_2} \times i$$

Although no such calculations are possible for the first experiment owing to lack of frequency data, it must be admitted that the yield of 3,267 kg. or 21,822 mature Tilapia with a mean weight of 150 gm. out of a total Tilapia weight of 3,617 kg. in ad 110 kg. of large, extraneous fish, was not in the second experiment, in which the w the upper five classes with a comparal frequency (19,032) averaged only 68 g and only in the upper three classes with number of 2,192 and a weight of 305 kg. d an average weight of the order of 150 gm.

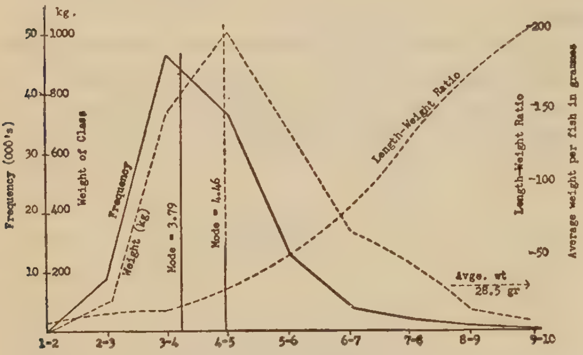

Fig. 1 Frequency Curves of *T. mossambica* raised in experimental pond at Bangkhen, 1954-55 (2nd Experiment)

Another purpose to which Fig. 1 may b future experiments is to achieve a compariso *condition* of the harvested fish. Obviousl tonnage of thin fish with a large proportion of material would be less valuable than a sc smaller crop in good condition, even if th frequencies were similar and a comparison length-weight curve in Fig. 1 and of the given in Table III should provide a good com of this factor in future experiments.

The estimated expenditure and income in of the second experiment were as follows :

TABLE IV

Estimated expenditure and income in second experiment (1954-55)

Interest on capital and depreciation	Baht	1,0
Cost of labour (1 full-time worker, 14 months)	,,	5,6
Cost of supplementary fish food		2,7
Fuel for cooking		8
Derris root and fertilizer		1
Pumping		5
(Note.—This can be saved if members of the family perform the work. Moreover, a full-time labourer could service a much larger area or alternatively perform other duties)....		10,8

Income :

Tilapia Fry 1″ - 3″	103 kg.		Baht 100*	
Tilapia Fingerlings, 3″ - 4″	726 ,,	@ 3 Baht/kg.	2,178	
Adult Tilapia, 4″ - 10″	2,337 ,,	@ 5 ,,	11,685	
Miscellaneous Fish	36 ,,	@ 5 ,,	180	14
Net profit				3

Breakdown of Supplementary Food :

	Kg.	Baht
Peanut cake	180	468
Rice bran	4,329	2,165
Broken rice	140	140
Pond vegetation	954	—
	5,603	2,773

It will be seen that more cooked food was administered during the second experiment and it is believed that a considerable economy may be achieved by reverting to the system adopted in the first experiment of giving a larger proportion of raw food. Pumping water for draining and filling the pond was also more costly and could be cons reduced.

The production of the 2,000 square met during the 416 days of the second experim 3,228 kg. of fish with a value of Baht 15,40 equivalent of about 14.2 metric tons per hec

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* A nominal figure, as the demand for fry on a sales basis has fallen off with the increased production of fry b individuals.

66 metric tons per acre per year). This is per hectare (1.5 metric tons per acre), or ent less than for the first experiment.

CONCLUSION

rd experiment has now been commenced in he lessons learnt in the previous ones will lized. Judicious weeding out of the ous fry will be carried out as breeding es and if these cannot be sold for lack of they will be utilized to feed predators in a pond, or alternatively as pig food. It is oted that the profits from pig raising carried a view to providing fertilizer has not been to account in either of the experiments.

the second experiment was in many less successful than the first, especially in the large proportion of small fish produced, it has been amply demonstrated that the production of fish in small ponds under tropical conditions may be considerably in excess of five tons per acre, and that such operations are a paying proposition, even after taking into account payment for work which normally would be performed by the members of the household. Moreover, the prices taken into account for calculating income are on the conservative side and would be considerably greater in inland areas.

ACKNOWLEDGEMENT

I am indebted to Dr. Cecil Miles, FAO Regional Fisheries Officer for Asia and the Far East, for assistance in the analysis of the production figures and the final editing.

5

EXPERIMENTATION IN THE BRACKISHWATER PONDS AT POLAGAN (MADURA, EAST JAVA)

by

Ab'd. Samad Djaingsastro*

It was well known in Indonesia that fish farmers suffer year after year from shortage of *Chanos* fry, while the yields of marketable *Chanos* are not satisfactory due to the very high mortality rate (75-90%)from fry to marketable size. This was the major reason for carrying out experiments at Polagan, Sampang Regency, Madura island, during the period 1950-1953.

The main aim of these experiments was to seek methods of lowering the mortality rate during the nursing period from fry to fingerlings as well as during the rearing period from fingerlings to marketable size.

Since its reconstruction and improvement in 1940, the Polagan plot was used for experimental and demonstrational purposes. As is usual with new brackishwater ponds, the yield during the first two and a half years was rather satisfacto after the Japanese occupation of the cou to 1950 the ponds were neglected, with th that the quality of the soil became worse topsoil had been washed off and *Cerithidiu* were abundant. In the middle of 1950 these were improved and the experiments could

Descriptive Data of the Experimental Ponds

Acreage	8.347 ha. including y dykes
	7.055 ha. including dy
Soil	Sandy loam with lime
Distance from sea	2-3 km.

Water supply: from a 3 km. long canal, from the sea.

Pre-war yield: *vide* table below:

Year	Rearing period Date of		Number of fish		survival %	Yield in kg.		
	stocking	cropping	stocked	cropped		*Chanos*	shrimps	other fish
1940 ..	June	Dec.	6,901[1]	3,978	58	704.55	—	6.5
1941 ..	Dec.	June	4,046[2]	4,032	99.6	673.45	62.5	107.52
	June	Dec.	2,287[2]	1,778	77.7	675.32	882.4	92.2
					Total for 1941	1,348.77	944.9	199.72
1942 ..	Dec.	June	3,397[2]	5,694	168	862.365	150.50	361.50
	June	Dec.	4,194[2]	1,598	26[3]	496.235	747.66	45.20
					Total for 1942	1,358.600	898.16	406.70

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* Chief, Inland Fisheries Service of East-Java Province, Surabaya, Indonesia.

Notes:
(1) Advanced fry
(2) Fingerlings
(3) Caused by flood.

Rainfall in mm.													Number of rain-days
Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
303	678	461	260	—	41	32	—	—	—	233	134	2,142	95
128	175	262	18	21	188	—	—	—	—	—	147	939	55
—	283	284	182	26	29	—	—	56	—	314	177	1,351	67
154	188	65	264	480	—	—	—	—	—	54	92	1,297	60

ration of the ponds.—One month before xing of fry, the ponds which were drained nd were further prepared. The bottom lled, holes in the dykes were stopped up baby-box in the centre of the nursery was . Bamboo screens were examined and with a piece of fine meshed netting.

main inlet of the pond was also provided amboo screen and netting, the water was vice before getting into the nursery.

ing.—During high tide sea-water was let nursery. The water had to pass through ves. Water came into the baby-box via of bamboo, also provided with a piece of When the water reached a depth of 15 cm., released in the afternoon. At this time ity of the water ranged from 25 to 35°/oo. remained in the baby-box during 24 hours y cutting the dykes of the baby-box at two e fry could disperse into the whole nursery. pose of the baby-box, which was 5 m. long wide was to facilitate observation of the fry he first few hours after stocking. The rate was 5,000 per hectare.

me of fry stocking was determined from the factors :

Availability of fry

Salinity of the water in the nursery ponds, influenced by weather conditions. The salinity at the stocking date of west monsoon fry ranged from 30°/oo to 40°/oo and at that of east monsoon fry from 25°/oo to 35°/oo. Water depth in the nursery ranged from 15 to 30 cm.

beginning of the experiments all the ponds sted with snails (*Cerithidea*). Eradication snails was attempted by using rice straw re. The result was that the number of creased and the fish grew better. Once a ier visiting the pond said 'tanah molae baras', which means (the soil is recovering from its sickness).

The dry season of 1953 was of long duration and as there was no possibility of renewing the pond water, the salinity increased continuously and the rearing duration of east monsoon fingerlings could not be extended. Early in October a number of fish in certain ponds died. The continuously increasing salinity gave an opportunity to determine the lethal concentration for several fish species.

Species	Lethal salinity
Chanos chanos	140 °/oo
Elops hawaiensis	125 °/oo
Mugil spp., *Leiognathus*, *Scatophagus argus*, *Therapon theraps*, Shrimps (*Peneus*)	70 °/oo

Rearing.—During the rearing period attention was paid to the maintenance of the water level and to the protection of the fish against pests such as birds and snakes.

Cropping.—Fingerlings were collected after having attained the length of 8-12 cm. weighing 6-10 grams. They were then transferred to rearing ponds to be raised to consumption size.

Collection was carried out by draining the ponds until there was water left in the marginal ditches only. By pushing a bundle of straw or the like, the fingerlings were driven towards the inlet. Though this operation was carried out at the time when clear water could be let into the pond, the water often became turbid on account of the movements of the labourers. The turbidity of the water affected the survival of the fingerlings. The fingerlings were caught near the inlet and immediately transferred into rearing ponds by means of a scoop net, a tin or an earthen jar.

Results of rearing from fry to marketable fish.—The following tables indicate the survival rates at both stages of the rearing, i.e. fro fingerlings and from fingerlings to marketal

West Monsoon Fry

Year		Ratio fingerlings to fry %	Ratio consumption fish to fingerlings %	Ratio consumption fish to fry	Ref. tab (Apper
1950	I	79.5	72.2	57.2	W. 1
	II	57.6	74.4	42.3	W. 2
1951	.. ..	80.9	81.2	65.7	W. 3
1952	.. ..	77.2	87.0	67.0	W. 4
Average	..	73.8	78.7	58.1	—

East Monsoon Fry

Year		Ratio fingerlings to fry %	Ratio consumption fish to fingerlings %	Ratio consumption fish to fry	Ref. tab (Apper
1951	.. ..	84.3	79.6	67.1	E. 1 ;
1952	.. ..	66.6	86.5	57.4	E. 2 ;
1953	.. ..	70.0	81.3	57.0	E. 3 ;
Average	..	73.6	82.4	60.5	—

CONCLUSION

From the results obtained during the three years of experimentation at Polagan (Madura island) the following conclusions can be drawn:

1. The number of fry needed for a unit of brackishwater pond can be reduced by lowering the mortality during the nursing period.
2. Lowering of the mortality can only be achieved by very careful preparation of the nursery. Draining and drying of the pond and sieving of the water are essential.
3. The quality of fry depends on the care bestowed on them from the time of collecting to that of their release nursery. In contradiction w opinion of some fish farmers fry in the rainy season is of a low and East monsoon fry has of quality than West monsoon fry.
4. The condition of pond soil wh become impoverished through i management can be improved by ing with organic matter, such straw.
5. Manuring with organic matter red degree of infestation with snails and gives better living co to the fish. Many snails continue to remain at a depth o

APPENDIX

RESULTS OF EXPERIMENTS

West Monsoon Experiments

Table W. 1: West Monsoon Fry 1950—I

Nursery No.	Acreage m^2.	Stocked		Cropped		Survival %	Du of R d
		Date	Number of fry	Date	Number of fingerlings		
1.	2,170	25-10-50	1,180	9-12-50	933	79.0	
2.	2,176	,,	1,180	,,	936	79.0	
3.	2,175	,,	1,180	10-12-50	900	76.0	
4.	2,232	,,	1,180	10-12-50	1,057	89.5	
5.	2,036	,,	1,180	11-12-50	878	74.0	
6.	2,001	,,	1,180	,,	895	75.8	
P.B.	3,000	,,	1,180	,,	973	82.5	
Total ..	15,790	—	8,260	—	6,572	79.5	

Table W. 2: West Monsoon Fry 1950—II

ery	Acreage m².	Stocked		Cropped		Survival %	Duration of Rearing days
		Date	Number of fry	Date	Number of fingerlings		
	2,170	27-12-50	540	15-3-51	300	55.5	89
	2,176	,,	520	14-3-51	345	66.0	77
	2,175	,,	500	5-3-51	295	59.0	62
	2,232	,,	590	,,	403	68.0	62
	2,036	,,	300	25-2-51	155	51.0	60
	2,001	,,	600	,,	324	54.0	60
	3,000	,,	300	22-2-51	107	35.6	57
..	15,790	—	3,350	—	1,929	57.6	—

Table W. 3: West Monsoon Fry—1951

ry	Acreage m².	Stocked		Cropped		Survival %	Duration of Rearing days
		Date	Number of fry	Date	Number of fingerlings		
	2,170	1-12-51	900	24-1-52	511	55.7	54
	2,176	,,	900	,,	742	82.4	54
	2,175	,,	900	25-1-52	738	75.3	55
	2,232	,,	900	,,	695	77.2	55
	2,036	,,	900	28-1-52	843	93.7	58
	2,001	,,	900	,,	842	93.6	58
..	12,790	—	5,400	—	4,371	80.9	—

Table W. 4: West Monsoon Fry—1952

ry	Acreage m².	Stocked		Cropped		Survival %	Duration of Rearing days
		Date	Number of fry	Date	Number of fingerlings		
	2,170	4-11-52	896	21-12-52	706	87.7	48
	2,176	,,	898	,,	747	83.1	48
	2,175	,,	898	,,	625	69.5	48
	2,232	,,	922	,,	733	79.5	58
	2,036	,,	840	,,	647	77.0	48
	2,001	,,	426	,,	618	74.2	48
..	12,790	—	4,880	—	4,076	77.2	—

S 2/5

East Monsoon Experiments

Table E. 1 : *East Monsoon Fry*—1951

Nursery No.	Acreage m².	Stocked		Cropped		Survival %	Du of Re da
		Date	Number of fry	Date	Number of fingerlings		
1.	2,170	23-5-51	850	8-7-51	767	90.2	4
2.	2,176	,,	850	,,	716	84.2	4
3.	2,175	,,	850	9-7-51	645	75.9	4
4.	2,232	,,	850	,,	816	96.0	4
5.	2,036	,,	800	16-7-51	617	77.1	4
6.	2,001	,,	800	15-7-51	653	81.6	4
Total ..	12,790	—	5,000	—	4,214	84.3	

Table E. 2 : *East Monsoon Fry*—1952

Nursery No.	Acreage m².	Stocked		Cropped		Survival %	Dur of R da
		Date	Number of fry	Date	Number of fingerlings		
1.	2,170	20-7-52	920	21-8-52	612	66.5	6
2.	2,176	,,	920	,,	568	61.7	6
3.	2,175	,,	920	,,	642	69.8	6
4.	2,232	,,	900	,,	688	76.4	6
5.	2,036	,,	920	,,	626	68.0	6
6.	2,001	,,	920	,,	528	57.4	6
Total ..	12,790	—	5,500	—	3,664	66.6	

Table E. 3 : *East Monsoon Fry*—1953

Nursery No.	Acreage m².	Stocked		Cropped		Survival %	Dur of R da
		Date	Number of fry	Date	Number of fingerlings		
1.	2,170	23-6-53	933	27-8-53	679	72.7	6
2.	2,176	,,	937	,,	640	68.3	6
3.	2,175	,,	935	,,	636	68.0	6
4.	2,232	,,	960	,,	625	65.0	6
5.	2,036	,,	875	,,	523	59.7	6
6.	2,001	,,	860	,,	747	86.8	6
Total ..	12,790	—	5,500	—	3,850	70.0	

Rearing Experiments of Fingerlings to Marketable Fish

Table F. 1: Fingerlings from West monsoon fry 1950—I

Acreage m².	Stocked		Cropped		Survival %	Yield in kg.		Duration of Rearing days
	Date	Number of fingerlings	Date	Number of fish		*Chanos*	Others	
11,813	9-12-50	1,200	14-4-51	1,009	84.0	15.528	64.500	95
7,696	9-12-50	969	16-2-51	845	87.2	67.600	7.000	68
10,764	10-12-50	1,055	25-2-51	9,960	91.0	54.000	15.500	77
2,336	11-12-50	245	22-2-51	215	87.7	25.000	8.000	73
8,514	10-12-50	1,073	7-2-51	715	66.6	71.500	22.500	58
9,482	11-12-50	1,152	25-2-51	880	76.4	45.500	13.000	77
6,490	11-12-50	878	27-2-51	132	15.0	2.472	20.000	78
57,095	—	6,572	—	4,756	72.2	281.600	150.500	—

Table F. 2: Fingerlings from West monsoon fry 1950—II

Acreage m².	Stocked		Cropped		Survival %	Yield in kg.		Duration of Rearing days
	Date	Number of fingerlings	Date	Number of fish		*Chanos*	Others	
11,813	25-3-51	300	1-6-51	270	90.0	69.660	3.000	86
7,696	25-2-51	224	15-6-51	180	80.3	36.000	4.000	110
10,764	5-3-51	307	16-6-51	217	70.7	47.740	—	103
2,336	25-2-51	100	9-6-51	37	37.0	4.200	—	104
8,514	25-2-51	362	1-6-51	282	77.9	77.740	2.500	109
9,482	5-3-51	391	22-6-51	291	74.4	7.800	2.500	109
6,490	14-3-51	245	9-6-51	160	65.3	9.300	2.500	87
57,095	—	1,929	—	1,437	74.4	252.440	41.500	—

Table F. 3: Fingerlings from East monsoon fry—1951

Acreage m².	Stocked		Cropped		Survival %	Yield in kg.		Duration of Rearing days
	Date	Number of fingerlings	Date	Number of fish		*Chanos*	Others	
2,170	15-7-51	151	14-10-51	111	78.8	17.000	1.500	80
2,176	,,	179	6-10-51	115	67.6	18.000	1.200	82
2,175	,,	162	,,	99	61.6	15.000	2.700	82
2,232	,,	170	7-10-51	134	78.8	18.400	2.750	83
2,036	16-7-51	100	2-10-51	93	93.0	18.000	0.500	78
2,001	,,	100	,,	98	98.0	22.000	0.500	79
10,764	8-7-51	1,067	19-10-51	806	75.50	85.600	3.000	95
3,000	16-7-51	100	9-10-51	97	97.0	13.000	0.500	85
6,496	,,	317	8-10-51	247	76.4	22.000	1.000	84
8,514	8-7-51	811	5-10-51	621	76.5	67.500	4.400	81
9,482	9-7-51	1,066	16-10-51	936	87.7	78.500	6.500	92
51,046	—	4,223	—	3,357	79.6	375.000	24.550	—

Table F. 4 : Fingerlings from West monsoon fry—1951

Nursery No.	Acreage m².	Stocked		Cropped		Survival %	Yield in kg.	
		Date	Number of fingerlings	Date	Number of fish		*Chanos*	Others
I.	11,843	24-1-52	850	17-6-52	739	86.9	158.500	6.500
II.	7,696	,,	570	2-6-52	480	84.2	95.500	5.500
III.	10,764	25-1-52	750	31-5-52	654	87.2	104.000	5.000
VI.	8,826	,,	731	28-5-52	494	67.5	79.500	22.000
VII.	8,514	28-1-52	770	29-5-52	616	80.0	79.750	7.350
VIII.	9,482	,,	700	30-5-52	566	80.8	96.500	14.850
Total ..	57,095	—	4,371	—	3,549	81.2	613.750	61.200

Table F. 5 : Fingerlings from East monsoon fry—1952

Nursery No.	Acreage m².	Stocked		Cropped		Survival %	Yield in kg.	
		Date	Number of fingerlings	Date	Number of fish		*Chanos*	Others
I.	11,813	21-8-52	721	10-12-52	585	81.1	140.000	9.100
II.	7,696	,,	514	8-12-52	454	88.3	70.500	18.700
III.	10,764	,,	667	6-12-52	573	85.9	85.000	15.000
VI.	8,826	,,	604	30-11-52	549	90.9	95.500	16.000
VII.	8,514	,,	555	2-12-52	481	86.7	93.200	16.000
VIII.	9,482	,,	603	4-12-52	508	84.0	104.800	33.200
Total ..	57,095	—	3,664	—	3,150	86.5	589.000	108.000

Table F. 6 : Fingerlings from West monsoon fry—1952

Nursery No.	Acreage m².	Stocked		Cropped		Survival %	Yield in kg.	
		Date	Number of fingerlings	Date	Number of fish		*Chanos*	Others
I.	11,813	21-12-52	833	15-3-53	748	90	182.500	8.000
II.	7,696	,,	543	,,	511	94	94.000	8.000
III.	10,764	,,	760	,,	566	75	62.500	6.700
VI.	9,496	,,	670	,,	618	92	104.600	17.250
VII.	8,514	,,	601	,,	570	90	83.700	21.600
VIII.	9,482	,,	669	,,	526	78	101.400	49.900
Total ..	57,765	—	4,076	—	3,539	87	628.700	111.450

Table F. 7: Fingerlings from East monsoon fry—1953

Acreage m².	Stocked		Cropped		Survival %	Yield in kg.		Duration of Rearing days
	Date	Number of fingerlings	Date	Number of fish		*Chanos*	Others	
11,813	27-8-53	833	16-10-53	739	88.7	30.500	—	50
7,696	,,	543	28-11-53	335	61.7	50.000	—	93
10,764	,,	543	18-10-53	383	71.7	17.800	—	52
9,496	,,	670	14-10-53	577	86.1	126.000	—	79
8,514	,,	601	23-11-53	565	96.0	121.000	—	88
9,482	,,	669	26-11-53	531	79.4	120.500	—	91
57,765	—	—	—	3,130	81.3	465.800	—	—

6

SOME NOTES ON ADULT *CHANOS*

by

R. Mardjoko Tjiptoaminoto*

e has ever seen the actual spawning of so for the time being it is not possible to exact spawning grounds. Several factors, and time of capture of mature specimens, d time of occurrence of fry, location of f adult *Chanos* observed etc. lead to the ry conclusion or assumption that *Chanos* the following localities.

orth Sumatra

ose to the shores of Acheh at places at a depth of about 50-70 m., with sandy bottom or presence of reefs.

the Malacca strait between North Sumatra and the Malay peninsula, nearer to the latter.

est Java

e Java sea, about 12 miles from the coast, cept in the Krawang area about 3 to 5 miles rom the coast.

ntral Java

Java sea, 6-12 miles from the shore.

(d) *East Java*

in Madura Strait in the vicinity of Djangkar Reef, between Madura island and the coast of Besuki.

(e) *Lesser Sunda Islands*

1. in the Flores Sea, between Bali and South Celebes.
2. Indian Ocean, South of the island Bali and Lombok.
3. probably also close to the coast of Northern Australia.

(f) *Celebes*

1. Around the Spermonde Archipelago.
2. Gulf of Bone, between Siwa and Kolaka.
3. Gulf of Poso.

(g) *Borneo*

in the vicinity of the isle of Gelam, 35 miles Kesouth of tapang.

---

d Fisheries Service, Surabaya/Madura Region, Surabaya, Indonesia.

In recent times schools of adult *Chanos* have been observed at the following localities.

(*a*) Java sea
  1. North of Tuban (East Java).
  2. North of Sidaju (East Java), in the months October and November.

(*b*) Madura Strait
  1. North of Pasuruan, July 1954, February 1955, at 17 hours, high tide.
  2. Same locality, month of observation not mentioned, time 10-12 hours.
  3. North West of Panarukan, date unknown, time 10-12 hours.
  4. North East of Panarukan, October 1946, time not mentioned.

(*c*) Bali Strait (between Java and Bali), August 1954.

(*d*) Alas Strait (between the islands of Lombok and Sumbawa), mostly in September 1954 from 6 to 10 o'clock in the morning and in October 1954 from 16 to 18 hours.

(*e*) Gulf of Poso, date not specified, time from 6 to 18 hours.

(*f*) Gulf of Bone, normally in October at about 10 o'clock in the morning.

(*g*) Banda-sea, near Kei islands, March 1955.

DENSITY AND BEHAVIOUR OF *CHA* SCHOOLS

Schools of *Chanos* observed could be reco by the repeatedly frequent leaps of the Beside schools of 10 to 15 specimens, also sch several hundreds (100-700) were noticed. reports mentioned schools of 15m. long a wide.

Normally the schools swim at the surface, top of the caudal fin is visible. At interva disappear beneath the surface for a couple of m This occurs however only in places where th is clear.

In the Gulf of Bone the adult fishes prefer waters ; so they may approach the shore and times enter river-mouths.

Most interesting is the phenomenon that of *Chanos* are repeatedly observed in the mouth rivers Poso, Bega and Tongko, which flow i Gulf of Poso. At noon the schools swim rivers and go back to the rocky parts of the se afternoon.

In the Gulf of Bone (Celebes) adult fishes the coast line during high tide and enter the The people are aware of this habit and ta opportunity of catching them by means of types of gear.

It is also noticed that East of Lombok, schools swim against the sea current.

7

THE BIOLOGY AND FISHERIES OF THE HILSA, *HILSA ILISHA* (HAMILTON)—*A REVIEW*

by

T. V. R. Pillay*

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ISTRIBUTION AND HABITAT

Hilsa, *Hilsa ilisha* (Hamilton) is known to om the Persian Gulf, along the coasts of kistan, coast of India and East Pakistan to ascending the major river systems. Hilsa the river Tigris in Iran and it provides a rich n the river Indus in West Pakistan. On the st of India, this fish is caught in large numbers coastal waters of Saurashtra and northern listricts of Bombay State. They ascend the River and are also known to occur near the of the rivers Purna, Tapti and Ulhas, north ay and in the rivers Savitri and Kali, south ay (Kulkarni, 1951). Chacko and Ganapati ave recorded the species from the west coast ras State, where they are reported to be ıre. On the east coast of India it occurs in shore areas and the estuaries of Godavari, and Cauveri.

g the monsoon the fish ascends also the rivers such as Korayar and Pamaniyar Dist.), the Vellar and the Palar (South Arcot Dist.), the Pennar, Manneru and the Uppeteru (Nellore Dist.). But on account of the construction of dams and anicuts across these rivers, their range of occurrence has been considerably restricted and at present there is a fishery of some magnitude only in the River Godavari. In the State of Orissa, Hilsa are caught in appreciable quantities from the Mahanadi estuary and the Chilka lake, as also the Balasore coast. In West Bengal and East Pakistan where Hilsa affords the richest fishery, they are found in the estuaries throughout the year, and ascend the rivers both in the monsoon and winter seasons. Coastal fishing for Hilsa is also prevalent in the Midnapore and Chittagong coasts. In Assam they ascend the Brahmaputra as far up as Tezpur. The Ganga river in Bihar and Uttar Pradesh also provide lucrative Hilsa fisheries whereas the rivers Yamuna and Tons in Uttar Pradesh yield a somewhat moderate fishery.

RACIAL COMPOSITION OF STOCKS

The possibility of there being different races of Hilsa in the Gangetic system of rivers was conceived at a very early stage of Hilsa investigations in Bengal. Jenkins (1940) while reviewing the studies conducted till then suggested, on the analogy of the herring fisheries in Europe, that there may be different races of Hilsa. Hora (1940) suggested that the Hilsa of the Hooghly and East Bengal might represent separate stocks. Naidu (1939) was of the opinion that there is not sufficient evidence to prove that the fish known as Jatka in East Bengal is really young of Hilsa and that the likelihood of there being different stocks has to be investigated. Pillay (1952) from a preliminary biometric study showed that there are probably two stocks of Hilsa in the area. One stock was represented by samples collected from East Bengal in February and March and from Orissa in July, September and November. Samples belonging to the other stock were present in East Bengal in March, April and May and in West Bengal in March, May and June. This study also indicated that the Hilsa stocks of the River Ganga near Allahabad remain distinct from the others. Pillay (1955*a*) studied samples of monsoon and winter

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search Officer (Estuarine), Central Inland Fisheries Research station, 47/1 Strand Road, Calcutta-7, India.

runs of Hilsa in the River Hooghly with a view to determining whether they represent different stocks, and from a detailed examination of body-measurements and scale, scute and vertebral counts concluded that the Hilsa of this river consisted of a homogeneous population.

The morphological and physiological characteristics of the blood of Hilsa from the River Hooghly were also studied by Pillay (1954 and 1955*c*). He recognised three blood groups among the fish in the Hooghly and established the pattern of their distribution. The erythrocyte counts, haemoglobin contents, coagulation period and size of erythrocyte cells and nuclei of Hooghly Hilsa have been determined.

The comparison of the morphometric data of a small sample of Hilsa from the Chilka lake with the standard data for the Hooghly stock has shown statistically significant differences in some of the characters (Pillay, 1955*a*). Sujansinghani (1955) has observed significant differences between the length-weight relationship of Hilsa samples from Burrabalong estuary in Orissa and Hooghly River.

LENGTH-WEIGHT RELATIONSHIP AND CONDITION

Pillay (1955*b*) found that the equation of exponential growth, $W = Ae^{bL}$ is superior to the equation $W = CL^n$ in describing the length-weight relationship in the case of Hilsa. The equations describing the relationship for the adults and immature fish are as follows:

Adults: $W = 10.0249\ e^{0.1092L}$
Immature: $W = 0.1402\ e^{0.4085L}$

Study of the seasonal fluctuation in the gonad weight: body weight ratio of the fish in the River Hooghly showed high values during and until just after the monsoons and in late winter (January to February) which are the breeding seasons. Fluctuations in the visceral weight: body weight ratio are not very marked. Slight increase in the ratios noticeable at the end of the breeding seasons, is probably due to increased intensity of feeding of spent fish. The increase in the ratios at the end of the winter months may also be correlated with the rich growth of plankton in the river, which forms the food of the fish. The fluctuations in relative condition values provide supporting evidence regarding the spawning season. A comparison of the seasonal variations in relative condition, gonad weight: body weight ratio and visceral weight: body weight ratio showed that the relative condition is greatly influenced by the gonad weight.

FOOD AND FEEDING

Southwell and Prashad (1918) inferred tha
Hilsa while ascending the rivers do not feed,
stomachs of a very large number were foun
empty. Hora (1938 and 1940) described th
of the species from the young to the adult
based on material examined from the Water
at Pulta, Barrackpore. He found that it is a
ton feeder and that the closely-set sieve-li
rakers on the branchial arches are admirably a
for straining microscopic life. Young Hilsa b
20 mm. and 40 mm. in length feed mostly on c
and sparingly on copepods, Daphnia and
cods. Older specimens upto 100 mm. in
were found to feed on smaller crustaceans en
ted above and also on insects such as Coriixi
Chironomid larvae etc. and Polyzoa. Still
specimens upto 150 mm. in length include
shrimps in their diet. It was inferred that the
Hilsa feed at the bottom as specimens from b
river and the Water Works invariably show
presence of sand grains in the stomach. H
Nair (1940) made a special study of the food
young Hilsa in East Bengal rivers and fou
they feed on filamentous algae, diatoms and co
Fair quantities of sand grains were also fo
the stomachs. During February and March
constituted the bulk of the food eaten, while
the nor'westers (March-April) diatoms form
main item. Chacko and Ganapati (194
Malhotra (1955) have confirmed the earlier
that adult Hilsa is a plankton feeder. In th
Godavari as well as in the Ganges, it ha
observed by the above workers that the fish a
from feeding during their spawning migrati

Jones and Sujansinghani (1951) have i
that the species does not exhibit any selecti
feeding as far as the different items of plank
concerned. Spent specimens appear to feed
bottom, whereas young ones seem to be mi
feeders.

Jones and Menon (1952) observed that the
Hilsa larvae consisted mainly of diatoms and
pods. According to them, with further grow
juvenile fish feed on a variety of other pla
organisms. Larger quantities of sand grain
been found in the stomachs of spent Hilsa.

FECUNDITY

General observations on the fecundity o
has been made by certain previous workers,
more detailed study has been made recen
Pillay (1955*b*). He found that the relationsh
ween fecundity and body weight of Hilsa is
the equation being $F = 1.2662—0.00801$

ionship between fecundity and length is ial, the equation being $F = 0.9500\ e^{0.6539L}$. undity of the Hooghly Hilsa has been to range from 250,000 to 1,600,000.

MATURATION AND SPAWNING

873) observed that the Hilsa may attain urity at the end of the first year or at the of the second year. Jones and Menon ve mentioned that their observations in the Chilka lake and Mahanadi River corro- is. They indicated that the males become hen 8½″-10″ in length and presumed them one year old, while females become mature cond year when about 10½″-12″ long. It found by Pillay (1955*b*) that males of Hilsa er Hooghly mature when they are 16-17 cm. les when 19-20 cm. in total length. His ons did not provide any evidence to sup- general belief that male Hilsa mature earlier females during the spawning season. ttempts were made to artificially fertilize of Hilsa from 1910-1912 in Bengal, with a esuscitating the rivers or culturing them as d fishes. All these resulted in failure and nvestigators concentrated their attention on of breeding habits and development of the Madras State a Hilsa hatchery was estab- the lower anicut in Bobbarlanka and it is that the experiments in artificial fertiliza- Iilsa eggs were successful, but difficulties rienced in rearing the hatchlings to a size or liberation in rivers (Raj, 1917).

ell and Prashad (1918*b*) were of the opinion are no fixed breeding grounds for the fish erally accepted sense of the term and they reed wherever conditions such as weather, re and other undetermined factors are uring the rains. They stated that Hilsa to the seas are only rarely caught.

st positive evidence of the Hilsa breeding oghly in the neighbourhood of Pulta was by Hora (1938) when he identified the Hilsa from the Pulta Water Works tanks, they would have gained access only in the ggs or early larvae, because of the very ction space in the centrifugal pumps at s. From the occurrence of young Hilsa r beds during a greater part of the year, he hat probably the fish breeds in the river tensive period, though the peak period is rainy season. From the occurrence of and females in the settling tanks during season, he presumed that the fish can reed in confined waters also. As a result studies Hora and Nair (1940) stated that the fish breeds in the river throughout the year, the peak period being about July-August with a lower peak in May. These peak periods were found to be correlated with the flooding of the river owing to the southwest monsoon and the nor'westers respectively.

Jones and Menon (1950 & 1951) reported the presence of fertilized eggs and embryonic stages in the River Hooghly near Pulta. They stated that the breeding of Hilsa is very restricted, if not at a standstill, during the winter months of December and January, as pro-larvae and post-larvae were scanty in plankton hauls made by them during the period. They, however, indicated the possibility that it may even then be breeding lower down in the estuary where the temperature may be higher.

Studies of ova maturation made by Pillay (1955*b*) have shown that there are two distinct spawning seasons for Hilsa in the River Hooghly, one starting with the monsoon season and extending up to November and the other during winter from January to February. It has also been inferred that the fish spawn several times during a spawning season and that they do not breed in the lower reaches of the estuary. The fish that ascends the river in the winter months are those that have attained maturity for the first time and are about 1½ years old. The monsoon run consists of different age groups.

Southwell and Prashad (1918*b*) described the ovarian and fertilized eggs of Hilsa. According to them, the eggs are about 0.8 mm. in size and the fertilized eggs which are demersal absorb water and swell up to a size of about 1.8 mm. Nair (1939) described the larval stages and Kulkarni (1950) has described the early development upto the 4th day after hatching based on material obtained by artificial fertilization. Jones and Menon (1951) have also described the embryonic development and early larval stages of the species. Kulkarni (1950) has surmised that there is a lunar periodicity in the breeding of the fish in the River Narbada.

Jones and Sujansinghani (1951) stated that the breeding season of Hilsa in the Chilka lake is much shorter than in the Hooghly. They have observed ripe fish in the lake from August to October with September-October as the peak period, and concluded that Hilsa of Chilka lake breed in the lower reaches of Daya.

SEXUAL DIMORPHISM AND SEX RATIO

Southwell and Prashad (1918), Jones and Menon (1951) and Chacko and Ganapati (1949) have observed that the female fish attains a larger size than the males. Significant differences between the growth rates of male and female Hilsa of the River Hooghly were observed by Pillay (1955*b*). The maximum size of female Hilsa of the Hooghly was found to be higher than that of males. Observations on the sex ratio in the catches were also made, but Southwell and Prashad (1918*b*) found the results so various and inconsistent that they were unable to draw any definite conclusions therefrom. Chacko and Ganapati (1949) have found the proportion of males to females in the Godavari to be 1:9. Jones and Menon (1951) reported that the ratio of males to females is generally constant with a preponderance of males at the commencement of the breeding season and of females during the period of spawning. In several instances shoals happened to consist of individuals of the same sex, male or female. David (1954) in a survey of the fisheries of a short stretch of the River Hooghly near Barrackpore, observed a preponderance of females in the catches, the ratio being 1:10-12. A study of the Hilsa catches from the River Hooghly by Pillay (1955*b*) during different months has shown that there is no significant deviation from the expected ratio of 1:1 in the monsoon run of the fish in the river, and that the predominance of males in the winter catches is attributable to selective fishing. Females appear to move in the deeper zones of the river and surface nets operated during winter are not suitable for their capture. Observations of the catches from the River Ganga at Buxar (Bihar) have confirmed that there is no deviation from the expected sex ratio of 1:1 (Jhingran, 1955).

AGE AND GROWTH

Hora and Nair (1940) and Prashad, Hora and Nair (1940) attempted to use the scale method for determining the age and growth of Hilsa but finally found (Hora and Nair, 1940) that annular rings are formed on the scales whenever conditions of life become unfavourable, the frequency of which is not known. Chacko and Krishnamurthy (1950) observed that there is a fairly regular pattern of increase in the number of rings on the scales and expressed the opinion that the formation of rings coincides with the spawning act. Raj (1951) however, observed that even in the scales of a few weeks old Hilsa, two or more lines of growth occur. He found that in the young as well as adult Hilsa, these rings are too numerous to be annual and do not occur at regular intervals. Jones and Menon (1951) and Pillay (1955*b*) also observed that the scale markings may not be of much use in studying the age of Hilsa.

Chacko, Zobairi and Krishnamurthy (1940) concluded from a study of a large number of Hilsa scales that the number of radii on the scales represented the body length in inches. Based on the general statements of other workers on the growth rate of the fish, they estimated the probab months to be the same as the number of ra on the scales. Raj (1951) in a more deta sideration of this problem reported that relation holds good except in full grown he expressed doubts regarding the usef radii in estimating growth rate. Pillay studied this aspect in further detail and that the number of radii is highly variable ent scales of the same fish and concluded formation of radii is not correlated with the fish.

From the study of collections made isolated settling tank at the Pulta Water W which water is pumped in from the River every month and the surface water draw filtration, Hora and Nair (1940) have concl the rate of growth of Hilsa starting with the period is fairly rapid. A size of about 4 is reached during the first month while tw old young are approximately 80 to 89 mm length. At the end of the third month, grows to about 100 mm. while after four maximum size of about 130 mm. is attai the end of the 5th month it grows to about and thereafter grows at the rate of abou a month. Ten months to an year old spec just about 300 mm. in length. It was that the breeding is almost inhibited and th rate considerably slowed down during th months of December and January. Suja (1955) made a study of the growth of juve from the River Hooghly and concluded th first month after hatching they grow to abou and in the subsequent two to three months to 20 mm. per month. Thereafter the gr falls to about 10 mm. per month. Job (1 the rate of growth of Hilsa as approximate per month. From the analysis of length data of samples examined from the Hoogh (1955*b*) has concluded that male Hilsa atta lengths of 24.7 cm., 34.3 cm. and 39.3 females 26.5 cm., 39.1 cm. and 43.6 cm. and 3½ years respectively.

MIGRATIONS

Our present information on the migr Hilsa is largely based on observations of fis catches. Day (1873) described the an nature of Hilsa in the Gangetic rivers and s the fish spends a part of its life in the se from the shallow coastal belt. According in the Hooghly they continue their ascent out the south-west monsoon to nearly the year (Day, 1889). Prashad (1919) doubte

s really anadromous as the fish is found in the
almost throughout the year. Hora (1938)
ed that Hilsa is a permanent resident of the
mostly estuaries, and rarely goes out into the
Ie supported Prashad's (1919) contention
ilsa is not to be considered as a true anadro-
species. Based on the observations made in
adras Fisheries Department, Raj (1937) has
that the fish spends the first year of its life in
ver reaches of rivers and goes to the sea in the
ear. This has not been observed to be the
Bengal waters (Jones & Menon, 1951). Raj
has reported that shoals of Hilsa visit the
ay annually from November to May, when
lar sea fishery takes place.

lu (1939) in his report of the fisheries of
has made extensive reference to the mig-
of Hilsa in the Gangetic river. He referred
orts that Hilsa migrates as far as Patna and
s, more than 400 miles from the sea, and
that Hilsa ascends the Ganges from June to
nber. Based on the information that adults
dom, if ever, caught during the rest of the
t was presumed that they go far out into the
hich according to him is the natural habitat
fish. He stated that shoals of small-sized
of 9″ to 10″ size begin to make their appear-
October-November every year, in the fore-
of the Bay even down to Cox's Bazar and the
of rivers including Hooghly, evidently to
the rich plankton found there at that time.
short period of stay in the lower reaches,
mall-sized Hilsa are said to migrate higher up
als in about January-February. He also
that the small-sized Hilsa may be coming up
er even upto August and they usually swim
o the surface while the medium and bigger
wim slightly lower down towards mid-river.
eneral migration of adult Hilsa takes place
bout May or June and they disappear by the
week of October, when presumably they
to the sea. Very seldom are any spent fish
and he could not determine whether this was
the annihilation of the migrants by extensive
or because the spent fish in their return mig-
swim along the bottom. In view of these
ations, he considered that there is not suffi-
vidence to say that the Hilsa is not anadro-
He surmised that after the eggs are hatched
go down the streams to the sea and remain
ill they again appear on the foreshore in about
r. Probably some of the medium-sized ones
to the sea to ascend again the following year
it May and later, as big-sized ones. From the
ements of fish examined by him he found the
the majority group in March-April to be
to 11.0″, which had evidently grown to 12.0″-13.0″ in July and August. The majority size of the medium-sized fish was 15.5″ and of the big ones 18.0″.

Hora and Nair (1940) studied the Jatka caught in East Bengal rivers and stated that they are 2 to 5 months old Hilsa which migrate from estuaries into freshwater for feeding purposes. Prashad, Hora and Nair (1940) stated that the fish migrates into the sea during the first year of its life where it moves along the foreshore and does not go far out into the sea. Hora (1940) pointed out that among the mature Hilsa that swarm into the rivers during the flood season for spawning purposes, there are a number of young individuals also and that these travel far up before they become sexually mature. He stated that spawning takes place in the tidal waters and in the middle reaches of the large rivers and inferred that the floods and sexual maturity induce the fish in the sea to undertake the upward migration. Based on samples examined from Chandipore on the Balasore coast of Orissa, he tentatively concluded that Hilsa in all stages of growth are found in the sea all along the foreshore area and the fish caught in November are less than one year old and that the fish feeds and continues to grow in the sea except during November and February and possibly also during May-June. It was surmised that after leaving the rivers they do not go far into the sea, but move about in shoals in the estuaries and foreshores. Jones (1955) has surmised on the analogy of the American Shad that the winter migration of Hilsa is influenced by the rise in the temperature of water in January. Based on observations of fishermen's catches Pillay (1955*b*) concluded that Hilsa ascend rivers only for spawning and that the spent fish as well as their progeny migrate down the rivers. Lower estuaries and coastal areas form the habitat of the species. The observation that young Hilsa often referred to as the Jatka Hilsa which ascends rivers from January to February are mature fish migrating for spawning, is of special significance as the fishery for this size group has so long been considered to be destructive to young ones. Mitra and Devasundaram (1954) hold the view that Hilsa is a permanent resident in Chilka lake preferring the less saline waters.

Observations have also been conducted by previous investigators on the effect of weirs on the migration of the Hilsa. Southwell and Prashad (1918*b*) have stated that the effect of weirs in the Gangetic rivers is disastrous for the Hilsa fisheries. But their effect in Bengal and neighbouring States differ from that in Madras State, in that in the former States Hilsa are found only very exceptionally beyond the anicuts even though the water level on the two sides of the weirs may be the same. Hora (1940) expressed the opinion that there is no need for opening any hatcheries to compensate the effect of the weirs.

The extent of migration of the fish in the various river systems in India differs very greatly. In the Ganga River the fish is believed to migrate as far high as Agra and Delhi. Jenkins (1938) and Naidu (1939) indicated the possibility of the Hilsa in the upper reaches constituting separate stocks and the morphometric comparisons of samples (Pillay, 1952) supports this view. In the Mahanadi, Godavari, Krishna, Cauveri and the Indus the extent of migration of the species has been greatly affected by the construction of anicuts or dams. In the Mahanadi the fish have been observed to migrate upto the Naraj anicut which is about 60 miles from the river mouth. In the Godavari, Krishna and Cauveri the extent of migration is upto the lowermost anicuts which are located at distances of 60, 60 and 35 miles respectively from the river mouths. The migration of Hilsa in the Narbada is restricted to about 100 miles and this is suspected to be due to the high velocity of the current in the upper reaches. In the smaller rivers on the west-coast they migrate only to very short distances from the river mouth. At present the fish ascends only as far as the Sukkar Barrage in the River Indus. In all the rivers where such artificial barriers have been erected the fisheries are reported to have been adversely affected. The migrating fish gather below the obstructions and are caught in large numbers by the fishermen with disastrous effect on the fisheries (Devanesan 1952). Day (1873) considered it essential to provide fish passes to facilitate the migration of Hilsa to the upper reaches of rivers in which artificial obstructions have been constructed. He made observations on an experimental fish pass set up in the lower anicut of the Coleroon river and found it not suitable for Hilsa. A similar fish pass was constructed in the weir across the Mahanadi at Cuttack but this also proved to be a failure (Southwell and Prashad, 1918*b*). Later investigators have all expressed the opinion that it will not be feasible to erect suitable fish passes in Indian rivers. The possibility of setting up hatcheries near these obstructions and artificially propagating the species for resuscitating the rivers was considered in Madras and Bengal. Though artificial fertilization of eggs is reported to have been possible in the hatchery established in the Godavari, rearing of hatchlings was not successful and so these experiments did not lead to any fruitful results.

Besides the obstruction of rivers by the construction of weirs and anicuts, silting also appears to affect the migration of Hilsa. Chacko and Dixitulu (1951) have observed that when the water level in the river Godavari was low due to failure of floods and silting during the season in 1950, the fish migrated along the shore and afforded a lu
fishery on the Coconada coast.

ENEMIES AND PARASITES

Southwell and Prashad (1918) have reporte
the shark, *Carcharinus gangeticus* Müll and
the Gangetic porpoise, *Platanista gangetica* L
the Otter, *Lutra vulgaris* Erxl. and the M
Crocodilus porosus Schn., are the main enem
Hilsa in the Ganges.

The following parasites have been recorded
the Hilsa, but none of them has been obser
be lethal (Srivastava 1935*a*, *b* & *c* and 1941 ;
well and Prashad, 1918*a* and Tripathi (1955).

LIST OF PARASITES RECORDED FROM HILSA

Trematoda—Digena

- *Lecithaster indicus*—(From stomach)
- *L. extralobus*—(From stomach)
- *Clupenurus piscicolu*—(From stomach)
- *Sterrhurus monolecithus*—(From stomach)
- *Orientophorus breviichrus*—(From Intesti
- *O. gangeticus*—(From Intestines)
- *O. ilisha*—(From Intestines)
- *O. clupii*—(From Intestines)

Cestoda

- *Rhynchobothrius ilisha*—(Larval forms muscles)
- *Syndesmobothrium fillicole* (From muscles)
- *Ilisha parthenogenetica*—(From mesenter liver)
- *Gymnorhynchus gigas*—(From mesentery, and coelom)

Copepoda

- *Clavellisa ilishae*—(From Gill rakers)

Tripathi (1954) has indicated that the pa
fauna of Hilsa in different localities may sho
tinct differences which may prove useful i
tinguishing different Hilsa stocks. As an in
he cited the occurrence of the Copepod, *Cla*
ilishae which is found on Hilsa from the
Hooghly but not on Hilsa from Chilka.

From a study of the available information r
ing cholera endemicity in India and Hilsa
tions Pandit and Hora (1951) formulated the
thesis that the Hilsa may be the carrier of c
vibrios during inter-epidemic periods. I
gations conducted in Calcutta on this pr
showed that cholerogenic vibrios are not fou
Hilsa. Experimental studies have however
cated the possibility of cholera vibrios under
mutational changes in the gut of the fish.

RDINESS AND CULTURABILITY

the early investigations in Bengal, obser- ere made on the hardiness of Hilsa with a ssessing the possibility of keeping brood fish some time before they can be stripped for ertilization and ascertaining whether they can l for studies on migration. Southwell and (1918*b*) observed that when the fish nears the mere capture by a net and handling is to kill it. Immature and spent fish are less and often live for about 15 minutes after It has been found to live upto an hour after nder very favourable conditions, even though known whether it would survive if return- water. They observed that Hilsa generally ar the bottom but often come to the surface, rly when an obstacle like a weir is encoun- De (1910) has remarked that adult Hilsa is a swimmer and is not found below a depth of aidu (1939) considering the possibilities of ilsa remarked that it is a very delicate fish ies the moment it is caught in the net. nts conducted by Pillay (1955*b*) have at the collection and rearing of young Hilsa uite feasible. He was able to rear them in tanks for a period of about 9 months. His ons also indicate that it may be possible to for studies on migration, growth, etc.

FISHING METHODS

ety of fishing implements are employed apture of Hilsa. Seine and drag nets, drift se nets, dip nets, gill nets and stake nets commonly used for Hilsa fishing. (Naidu, nes and Sujansinghani, 1951 ; Kulkarni, hmed, 1954 ; Chacko, 1954 and Jones, Bag nets operated in East and West Bengal nerally catch juvenile Hilsa. Kaushiva as described a method of trapping Hilsa l in Uttar Pradesh (India). It is reported e Indus River where the water is relatively fishermen spear Hilsa from rafts.

ATIONS IN FISHERIES AND SIZE COMPOSITION OF CATCHES

on the examination of catches during a f the fisheries of Bengal, Naidu (1939) it they are generally composed of three size mall 9″ or 10″–12″, medium 12″–15″ and 18″ and he reckoned that they belong to r classes, which were reported to charac- catches every year. However, certain ps were reported to predominate during ears. David (1954) has observed that the ight by the fishermen near Barrackpore during September-October were generally larger and ranged between 271 mm. and 409 mm. compared to those obtained during July-August, which were 234 to 407 mm. in length. He also stated that none of the fish caught there during the winter season exceeded a length of 230 mm. Jones and Sujansinghani (1951) have presented data on the size composition of Hilsa examined by them from the Chilka lake but considered the material unsuitable for drawing any definite conclusions. Pillay (1955) has observed that the fishermen's catches in the upper reaches of the Hooghly River during winter consist of about 1½ year old fish and that there is selective fishing during the period. Throughout the winter season large number of juvenile Hilsa are caught in the bag nets. The adults caught from the river consist mostly of 3 year classes, viz. 1½, 2½ and 3½ year olds. The length frequency data of Hilsa catches from the Sunderbans (Sarkar, 1955) show that spent Hilsa are caught from the lower estuaries during winter. Mitra and Devasundaram (1954) reported that all size groups of Hilsa are caught by the fishermen from Chilka lake. Jhingran (1955) has reported that the fishermen's catches in Buxar (Bihar) consists of fish 22 to 48.5 cm. in length.

Mojumdar (1939) and Hora and Nair (1940) have observed that better catches of Hilsa are obtained during the spring tides. Kulkarni (1950) has inferred that there is a similar lunar periodicity in the Hilsa fishery in the river Narbada. Such a periodicity was not observed in the catches of the river Hooghly. (Pillay, 1955*b*).

It is generally believed that the Hilsa fisheries of India and Pakistan are fast getting depleted. This belief is largely based on complaints regarding the inadequacy of supplies in the markets and the increase in price. Detailed studies to assess the status of the fishery have not yet been undertaken. Based on the available data it is estimated that the total average production of Hilsa in India is about 16,000 tons. Marked fluctuations have, however, been noticed in the production from year to year.

Hora and Nair (1940) and Hora (1941) recorded that besides the annual fluctuations there is a five-year cycle in the Hilsa fisheries and this has been definitely observed since 1934. A similar periodicity has been observed in the Hilsa fisheries of Bihar (Varma, 1954) and Burma (Ba Kyaw—personal communication). While the ordinary fluctuations in the catches were explained by Hora & Nair (1940) as due to variations in the onset of the monsoon, long-range fluctuations were presumed to be because of large populations attaining maturity at particular periods. They examined samples of scales of specimens caught during the season of abundance in 1939 and inferred that the majority of them were five-year-olds with some three-year-olds. This was considered to indicate that though some individuals, generally males, become mature at the age of 2 to 3 years, the normal age at maturity of the species is 5 years. Every five years the bulk of the stock becoming mature swarms up the rivers and provides the bumper catches.

From a study of the statistics of Hilsa export from Chilka lake and the flood level over the Naraj anicut in the River Mahanadi along with the data on rainfall in the area, Jones and Sujansinghani (1951) presumed that the migration of Hilsa and consequently the abundance of Hilsa in the estuaries are directly correlated with the floods. Mitra and Devasundaram (1954), however, concluded from the examination of additional data regarding flood levels in the Mahanadi River that the fluctuations in Hilsa fisheries are probably influenced by the intensity of fishing and not by the flood levels.

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8

LONGLINE TUNA FISHING GROUNDS IN THE INDIAN OCEA

by

H. Nakamura,* Y. Yabuta and K. Mimura

Though it was suggested from the investigations which were carried out between 1930 and 1934 by the ships " Haruna-maru," " Hakuyo-maru " and "Shonan-maru" that the eastern waters of the Indian Ocean would be excellent fishing ground for tunas, no Japanese commercial fishing boat worked in these waters before World War II. A good catch, made by "Fukusei-maru No. 10" in the seas adjacent to Timor in autumn 1952, marked the turning-point, and the fishing ground in the Indian Ocean to the westward were exploited soon after.

The data furnished in this paper were obtained by Nankai Regional Fisheries Research Laboratory up to the end of March 1955. For convenience, the seas west of 120°E, excluding the inland seas of the Indo-Australian Archipelago, are treated as the Indian Ocean.

Principal Fishes

The principal fishes are *Indo-maguro* (Southern bluefin ?, *Thunnus thynnus macoyii*), *Bin-naga* (Albacore, *Germo germo*), *Mebachi* (Big-eyed tuna, *Parathunnus mebachi*), *Kiwada* (Yellowfin, *Neothunnus macropterus*) and several species of marlins. Because of the lack of the detailed taxonomic studies, it is not possible to determine whether they are the same species as those of the Pacific. Supposing, however, that they are the same, it is questionable whether there is sufficient interchange of individuals to have any effect on the populations of the two Oceans.

Outline of Distribution

1. *Indo-maguro*, Southern bluefin.—The distribution of this species seems to be restricted to the area from the north and west coast of Australia to as far as the adjacent seas of Sunda Strait, and it is quite rare in the Indian Ocean proper.

2. *Bin-naga*, Albacore.—This species essentially appears to be restricted to the southern waters of the Equator, and is especially dense in the waters south of 10°S. In some seasons, the distribution is considerably dense in the northern waters of the Equator, but the area seems to be limited to the east of about 90°E.

3. *Mebachi*, Big-eyed tuna.—This spe
distributed widely. Although the central
the distribution is not distinct, the density
to decrease gradually to the west and it is
rare in the seas south of 10°S.

4. *Kiwada*, Yellowfin tuna.—The distr
of this species is wider than that of the big-eye
and seems to be rather abundant in the seas
25°S in some seasons.

5. *Kajiki*, Marlin.—We have not yet g
enough knowledge to indicate the distribu
the Marlins.

Seasonal Variations in Fishing Conditio

There are as yet insufficient data to expl
seasonal variations in the fishing conditions
ing over the whole area of the Indian Ocean.
II-V show the fishing conditions by quarters
area between 110°—120°E. longitude and 10
latitude, where the data are comparatively abu

1. *Indo-maguro*, Southern Bluefin.—(Ta
Chart A, 1-4[1]).—The hooked-rate (num
fish caught per 100 hooks) is at a minimum b
June and July, and reaches over 2% in Sep
and February. The fishing ground extends
west as far as about 100°E. longitude b
January and March.

2. *Bin-naga*, Albacore—(Table III, Ch
1-4).—The most active season is between
and June, after which fishing activity d
gradually until October.

3. *Mebachi*, Big-eyed tuna—(Table IV,
C, 1-4).—The active season occurs betwee
and September and the seasonal change of the
condition is two or three months later than
the Albacore.

4. *Kiwada*, Yellowfin tuna—(Table V,
D, 1-4).—The active season is between
and January, and the maximum hooked rate
in January. The seasonal variations in the
conditions in other areas are not known. H

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*Nankai Regional Fisheries Research Laboratory, Kochi city, Japan.

[1] Charts A1, A2, A3, and A4 are retained at the Indo-Pacific Council Secretariat in so far as only negative
recorded although there were medium sized catches during all the seasons to the south of Java and the Lesser Sunda

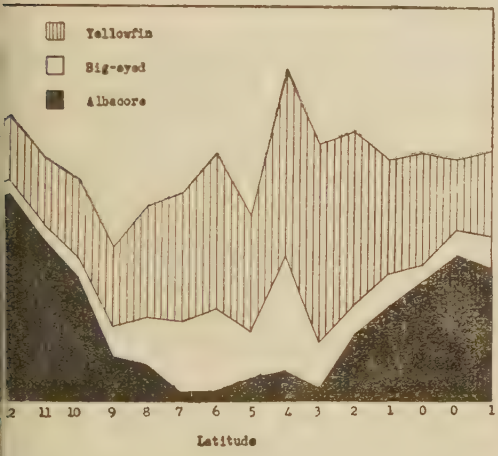
vaters north of the Equator the active season,
to be between January and June.

phic Distribution of the Fishing Grounds

the appended charts, which show the hooked-
each quadrate of 1° of longitude and latitude,
geographic distribution is only evident for
acore and Southern Bluefin. The regional
ns in the species and size composition are
ws :—

cies Composition

1 shows the hooked-rates by species in each
1° latitude by 10° longitude between 90°
0° E. longitude. The season is between
d September. Within the limits of Fig. 1,
owing facts are observed.



. The hooked-rate by species in each latitude
etween 90° and 100° E. (July-September)

he grounds where Albacore is the principal
ccur in two areas, one situated along the
and the other along 12°S. latitude.

ellowfin tuna is most abundant around 5° S.
dually decreases to the north and south.

he changes in the hooked-rates of the Big-
na show a similar tendency to those of the
n tuna.

bove facts indicate that there are two types
ing grounds, one where the principal
ent of the catch is Albacore and the other
he Yellowfin is the most abundant. The
ies of these grounds seem to lie around 3°S
. latitudes.

On the fishing grounds in the Pacific Ocean, Nakamura (1952) explained that :—

(i) The areas corresponding to the different ocean currents are likely to produce fishing grounds with individual characteristics, and if there are no extraneous factors such as topography, the change in the character of the fishing ground is gradual in the same ocean current.

(ii) The change is likely to be sudden when the grounds are separated by the boundary between the currents.

The outline of the distribution of the ocean currents in the area of Fig. 1 is shown in Fig. 2.

From Fig. 2, it may be deduced that the fishing ground around 8° S. latitude corresponds to the boundary between the Equatorial Counter Current and the South Equatorial Current. The Albacore fishing ground located north of 3°S. latitude is isolated and corresponds to the area where the currents are not well defined, which seems to suggest that there will be a different circumstance.

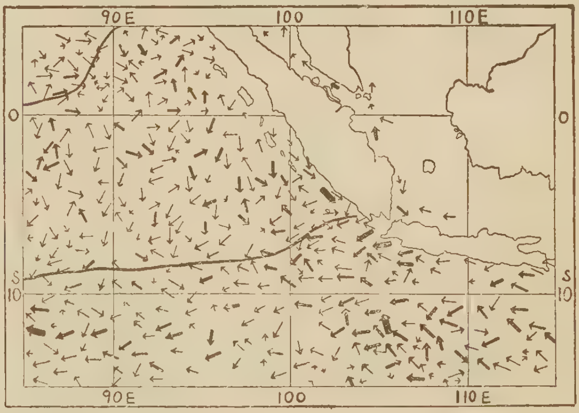


Fig. 2. Ocean currents in the Indian Ocean (between 85° and 115° E, 5° N and 15° S).

Fig. 3 shows the hooked-rates by species in each degree of longitude between 0° and 10°S. latitude. As is shown in Fig. 3, the hooked-rates of the Yellowfin show a tendency to increase gradually to the west, whereas, the hooked-rates of the Albacore decrease gradually westward, except in the area east of 90°E where it is assumed that special circumstances prevail.

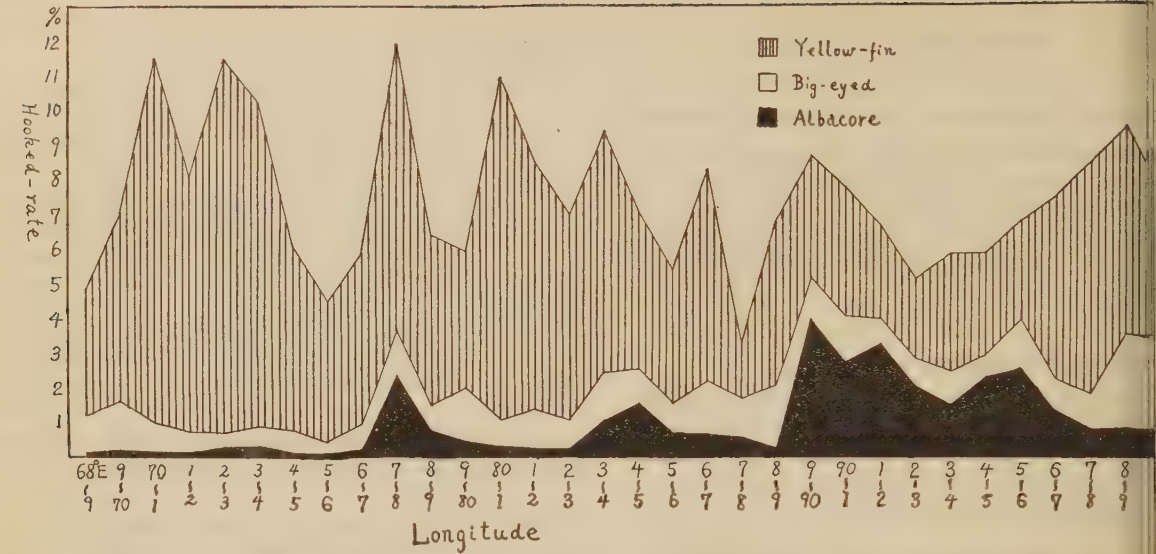


Fig. 3. The hooked-rate by species in each degree of longitude between 0° and 10° S. (July-Sept.)

The difference in species composition according to the difference of the ocean currents is rather clear from the unpublished results obtained by Yabuta during the investigation of the 'Tone-maru' as shown in the following table.

TABLE I

Species composition by areas

Area	Yellowfin %	Big-eye %	Albacore %	Marlins %	Total
A. 66°-69° E 4°- 6° S	95.3	2.1	1.0	1.6	100
B. 57°-61° E 3°- 6° S	93.5	2.0	0.3	4.2	100
C. 57°-60° E 8°-12° S	85.6	0.0	9.0	5.4	100
D. 51°-64° E 15°-25° S	45.8	0.6	34.6	19.0	100

The greater part of zones A and B are in the Equatorial Counter Current area; C occupies the area where the currents are indistinct, and D is the area of the South Equatorial Current (Fig. 4).

(b) **Size Composition**

Fig. 5 shows the size composition of the Yellowfin according to Yabuta (unpublished). A-D correspond to those of Table I.

Modes appear at the lengths around 127 and 139 cm. in areas A and B, and the proportion of the small sized to the large sized decreases in area B more than in the area A.

The condition in area C differs remarkably from those of areas A and B, a marked mode appearing at the length around 155 cm.

It is hard to say anything definitely, becau
area is wide and the data are poor for area
the curve appears to differ from those of A-C.

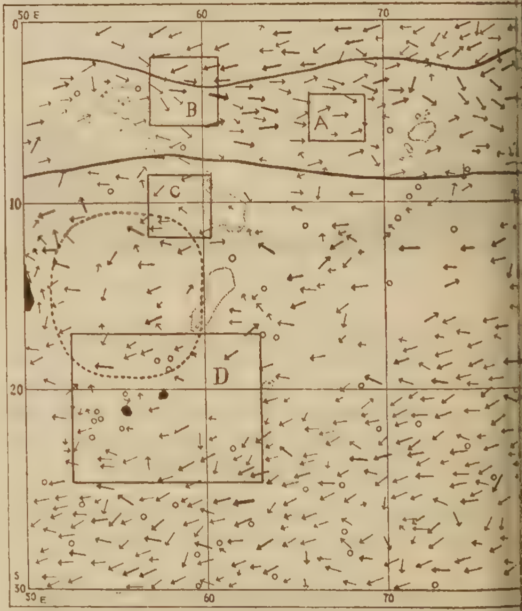


Fig. 4. Ocean currents in the Indian Ocean (bet
50° and 80° E, 0° and 30° S).

Fig. 5 proves the difference of the cha
between A, B and C, which is not clear in Tab

As for the other species we have not yet obt
much data—several examples of Albacore
shown in Fig. 6. The size composition in

in the order of the ships, and all the data ned in January and February, except (d).

lly speaking from Fig. 6, it can be :—

he size of the Albacore is smaller in the East, and becomes gradually larger towards the West.

The relation in the south/north direction is not evident, but at least within the limits of (a) and (b) of the figure, the fish is smaller in the north, more or less along the same longitude.

ze of the Albacore in the North-western larger in the East and smaller in the North, latitude and longitude are respectively . Not only the Albacore in the North- acific, but also the Tunas and Marlins in the acific show a tendency towards larger size.

ndency to larger size towards the West lian Ocean is not only observed in Albacore, in Yellowfin (Fig. 6). Therefore, it may hat in the Indian Ocean, the inclination of compositions of Tunas in the East-west is just the reverse of that of the Pacific.

ing to Yabuta (unpublished), the regional s in the size composition of the Yellowfin ht to be based mainly on the differences -ratio. The same phenomenon is reported y (1952) in the Pacific.

it is surmised that the ocean currents in of the Indian Ocean studied correspond hing grounds for Tunas but bear a reverse ce from those of the Pacific.

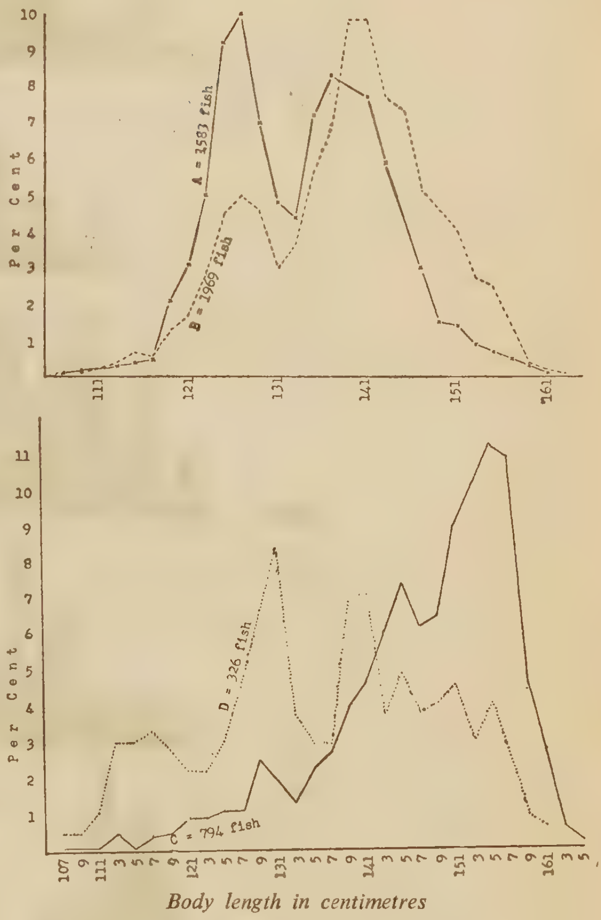


Fig. 5. Size composition of Yellowfin catches.

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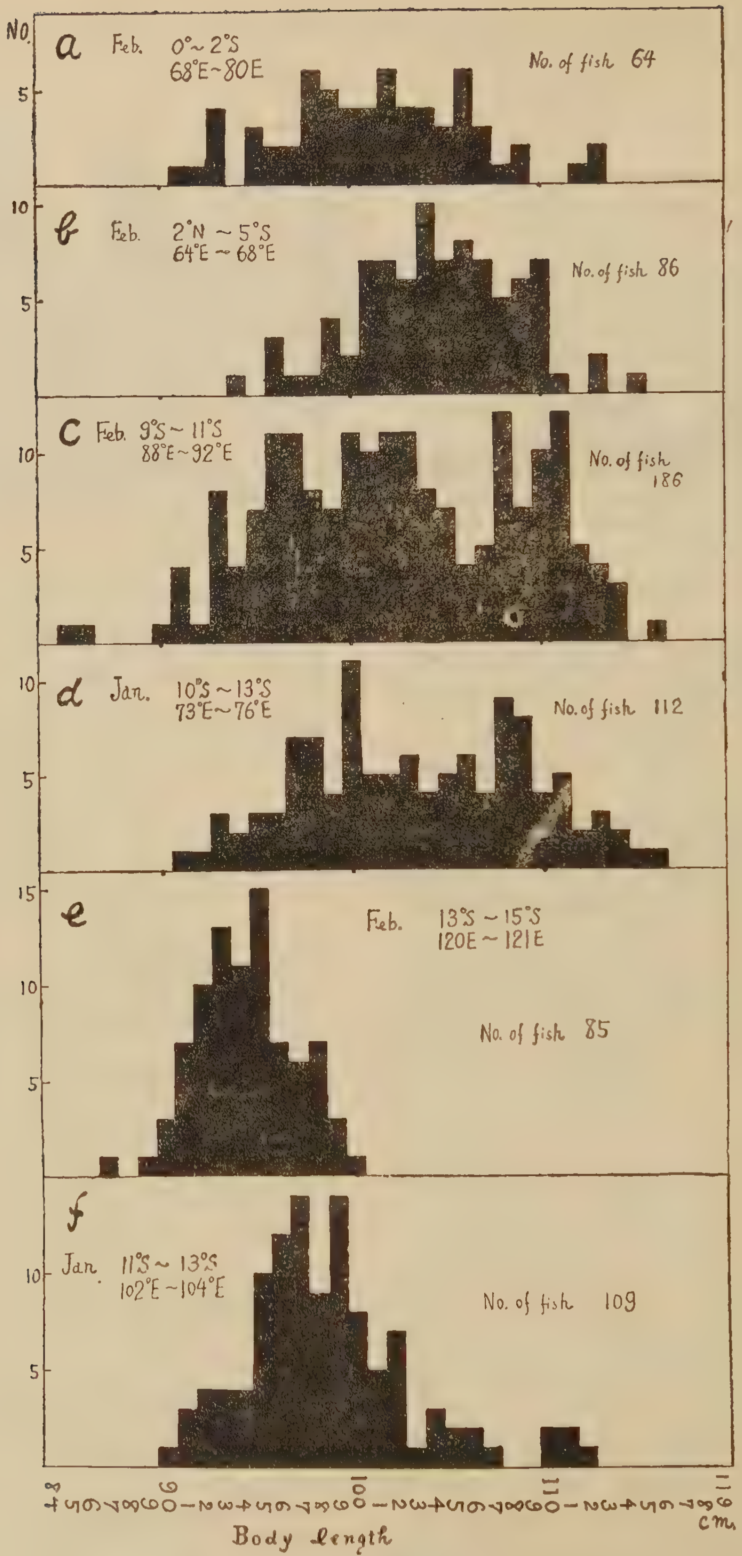

Fig. 6. Size composition of Albacore by fishing vessels.

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TABLE II

Hooked-rate Frequency by Month (Southern Bluefin)

h	Hooked-rate								
	0	0.0-0.50	0.51-1.00	1.01-2.00	2.01-3.00	3.01-4.00	4.01-up	Total	Mean
	0	3	7	18	4	6	0	38	1.54
	14	0	1	7	12	0	9	43	2.02
	3	13	12	42	21	2	3	96	1.45
	6	15	15	2	3	0	0	41	0.63
	17	63	0	0	0	0	0	80	0.08
	109	28	0	0	0	0	0	137	0.01
	137	12	0	0	0	0	0	149	0.01
	32	8	17	7	0	0	0	64	0.40
r	14	22	0	3	3	1	38	81	2.73
	0	7	25	24	0	6	5	67	1.54
.	0	17	44	57	6	4	1	132	1.16
	23	3	31	18	2	0	0	77	0.71

TABLE III

Hooked-rate Frequency by Month (Albacore)

n	Hooked-rate								
	0	0.01-0.50	0.51-1.00	1.01-2.00	2.01-3.00	3.01-4.00	4.01- up	Total	Mean
	18	10	3	4	0	3	0	38	0.56
	2	13	0	20	8	0	0	43	1.35
	5	10	9	20	10	25	17	96	2.24
	0	8	2	2	3	13	13	41	2.98
	0	0	0	15	5	4	56	80	4.00
	0	0	0	1	27	21	88	137	4.42
	4	36	11	21	32	10	35	149	2.31
	6	2	7	37	5	5	2	64	1.56
	6	29	4	24	8	0	10	81	1.74
	9	46	0	5	5	2	0	67	0.54
	19	60	2	7	27	16	1	132	1.05
	16	13	14	21	13	0	0	77	0.97

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TABLE IV

Hooked-rate Frequency by Month (Big-eyed tuna)

Month	Hooked-rate							
	0	0.01-0.50	0.51-1.00	1.01-2.00	2.01-3.00	3.01-4.00	4.01-up	Total
January	2	31	3	2	0	0	0	38
February	2	38	3	0	0	0	0	43
March	2	87	7	0	0	0	0	96
April	0	18	21	2	0	0	0	41
May	0	28	44	8	0	0	0	80
June	0	48	70	14	5	0	0	137
July	0	41	12	47	30	16	3	149
August	0	24	27	10	3	0	0	64
September	0	34	18	26	3	0	0	81
October	0	3	22	38	4	0	0	67
November	1	38	72	20	1	0	0	132
December	5	40	13	19	0	0	0	77

TABLE V

Hooked-rate Frequency by Month (Yellowfin tuna)

Month	Hooked-rate							
	0	0.01-0.50	0.51-1.00	1.01-2.00	2.01-3.00	3.01-4.00	4.01-up	Total
January	0	0	1	8	3	8	18	38
February	0	1	4	8	9	16	5	43
March	1	4	9	47	15	13	7	96
April	0	1	11	5	5	13	6	41
May	0	3	0	27	19	11	20	80
June	0	2	37	68	10	3	17	137
July	0	26	40	6	27	37	12	149
August	2	8	10	31	3	9	1	64
September	0	32	3	14	17	6	9	81
October	0	2	0	8	14	31	12	67
November	1	0	8	48	13	8	54	132
December	0	3	2	29	6	0	37	77

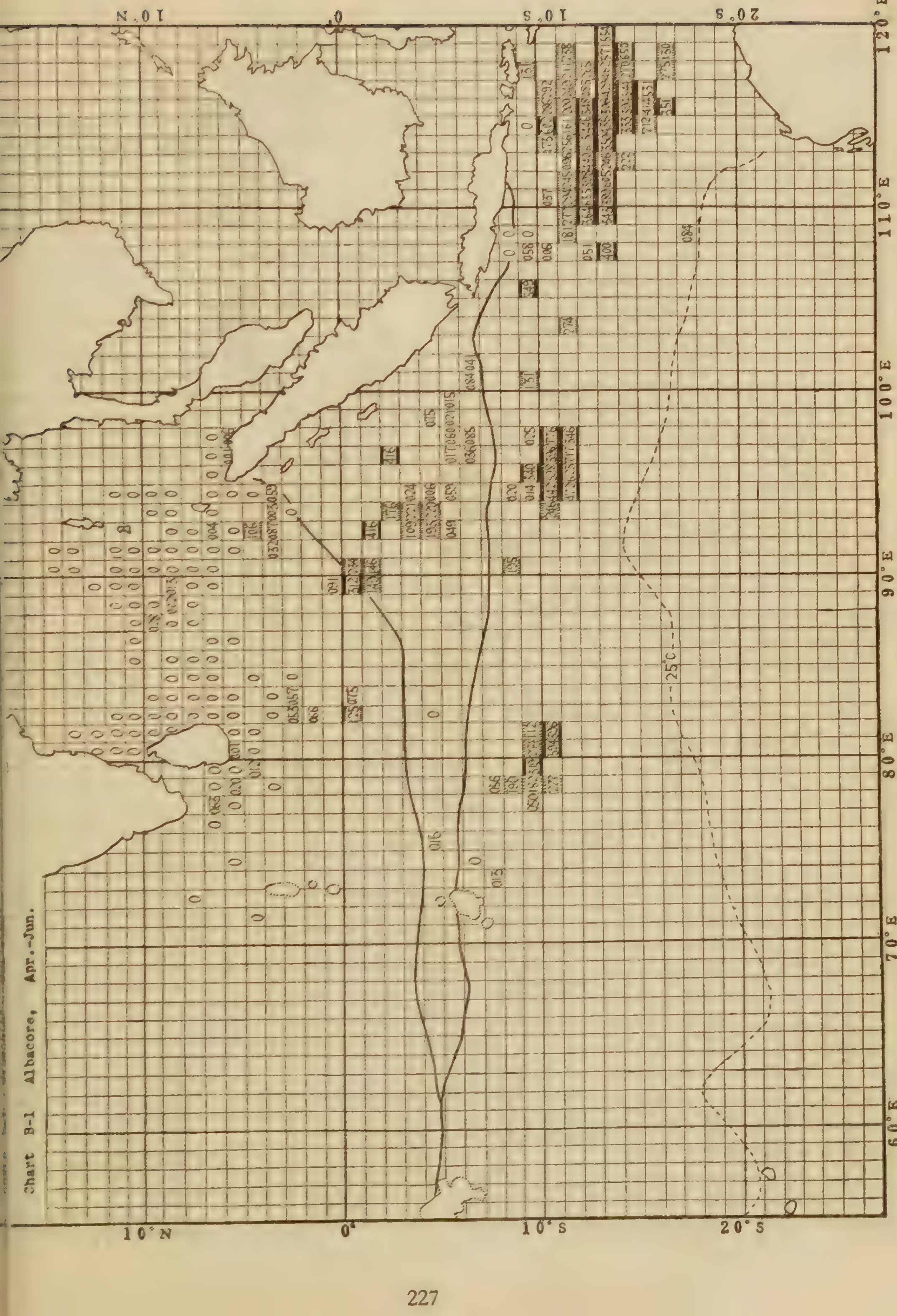


Chart B-1 Albacore, Apr.-Jun.

10°N
0°
10°S
20°S
120°E
110°E
100°E
90°E
80°E
70°E
60°E
25°C

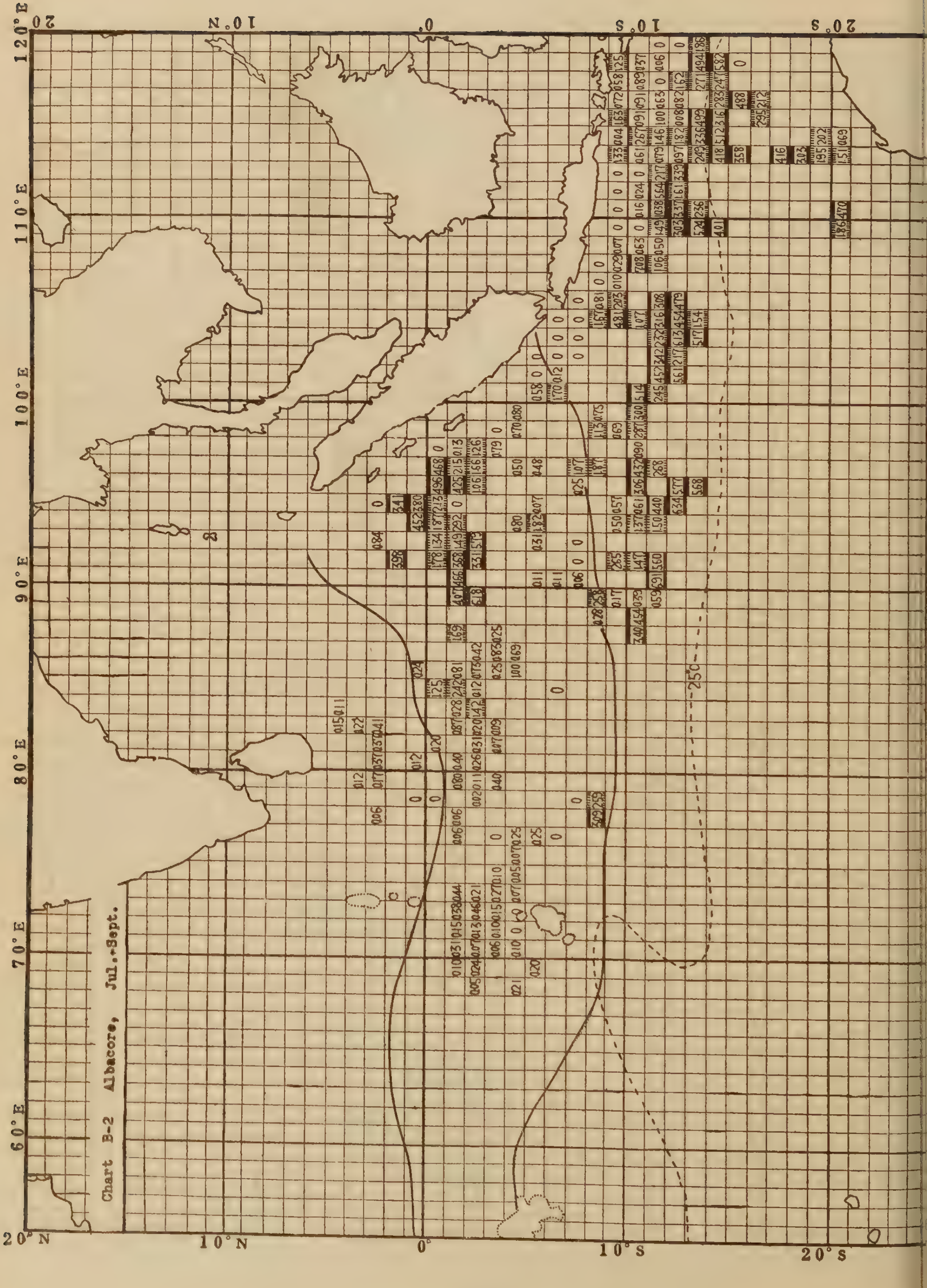

20°N
10°N
0°
10°S
20°S
120°E
110°E
100°E
90°E
80°E
70°E
60°E
25°C

Chart B-2 Albacore, Jul.-Sept.

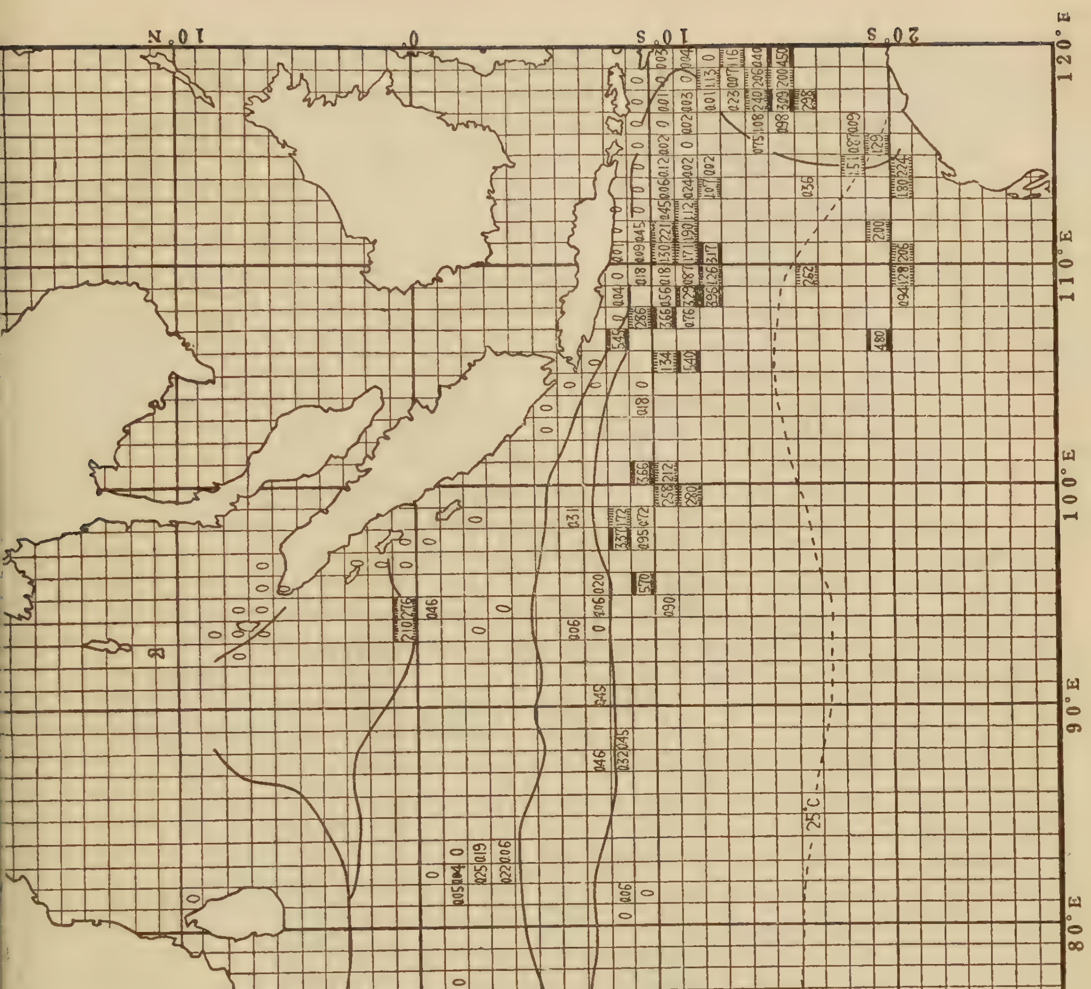


Chart B-3 Albacore, Oct.-Dec.

10°N
0°
10°S
20°S
120°E
110°E
100°E
90°E
80°E
70°E
60°E
25°C

S 2/8

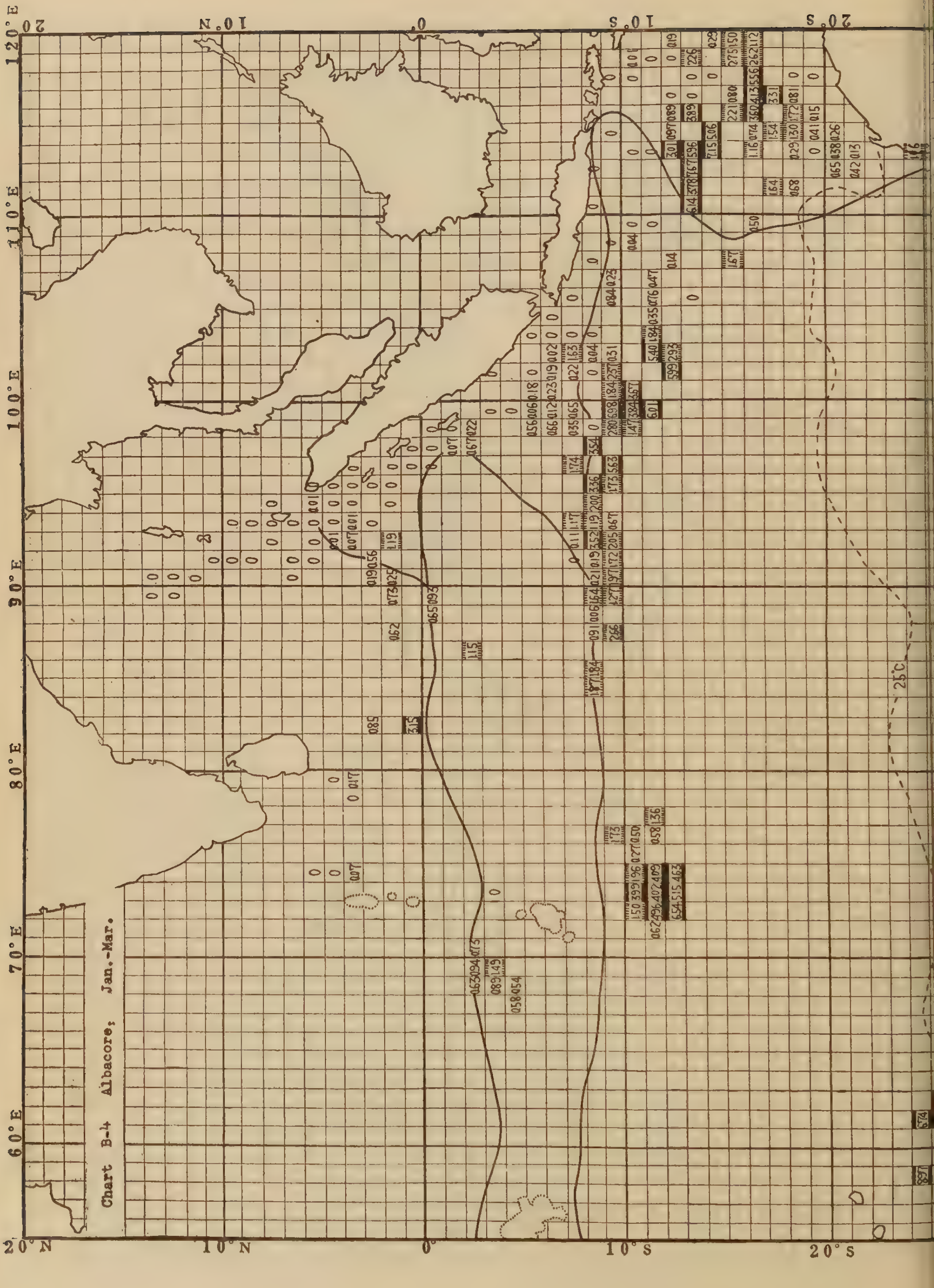

120° E
110° E
100° E
90° E
80° E
70° E
60° E
20° N
10° N
0°
10° S
20° S
25°C

Chart B-4 Albacore; Jan.-Mar.

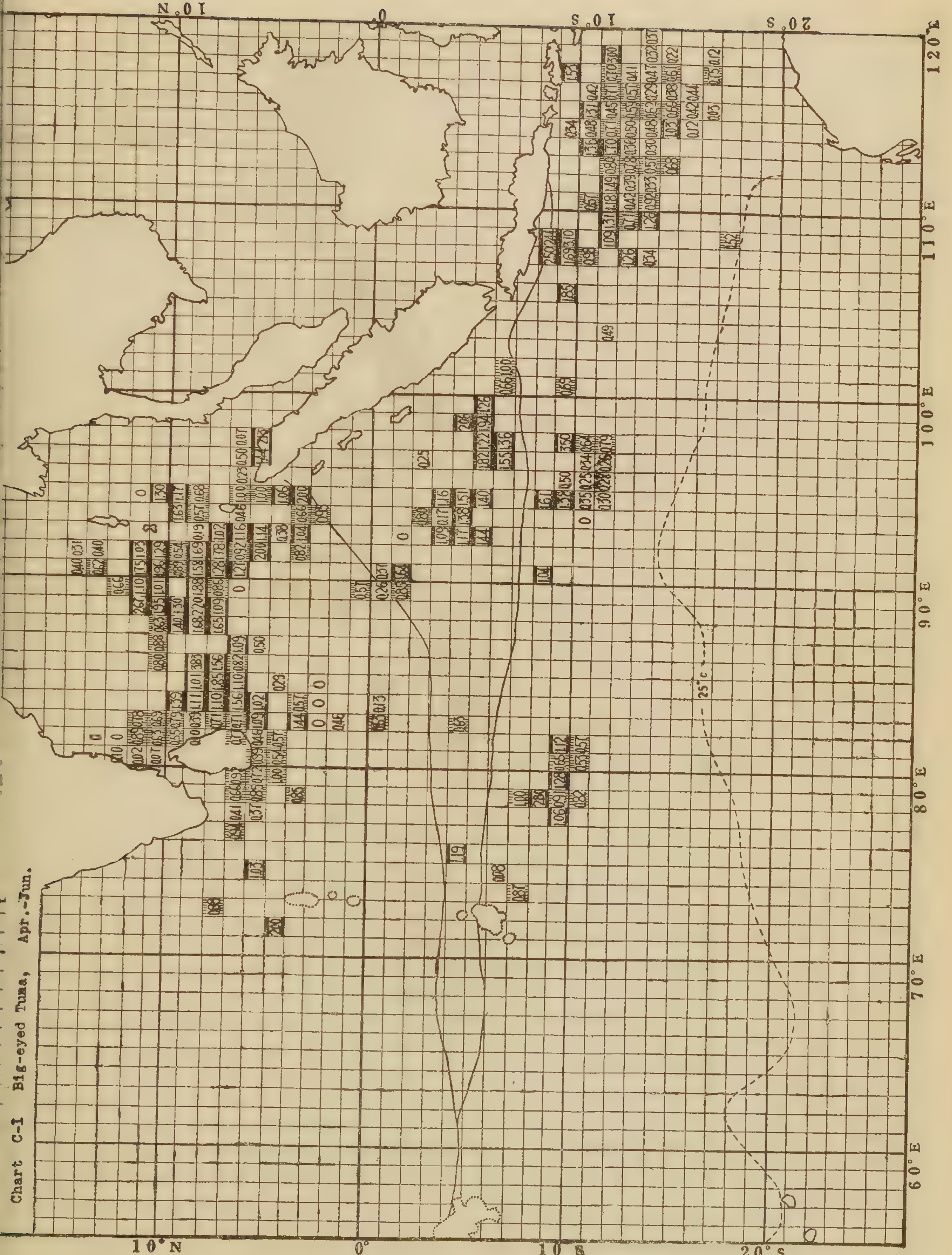

10°N
0°
10°S
20°S
120°E
110°E
100°E
90°E
80°E
70°E
60°E
25°c

Chart C-1 Big-eyed Tuna, Apr.-Jun.

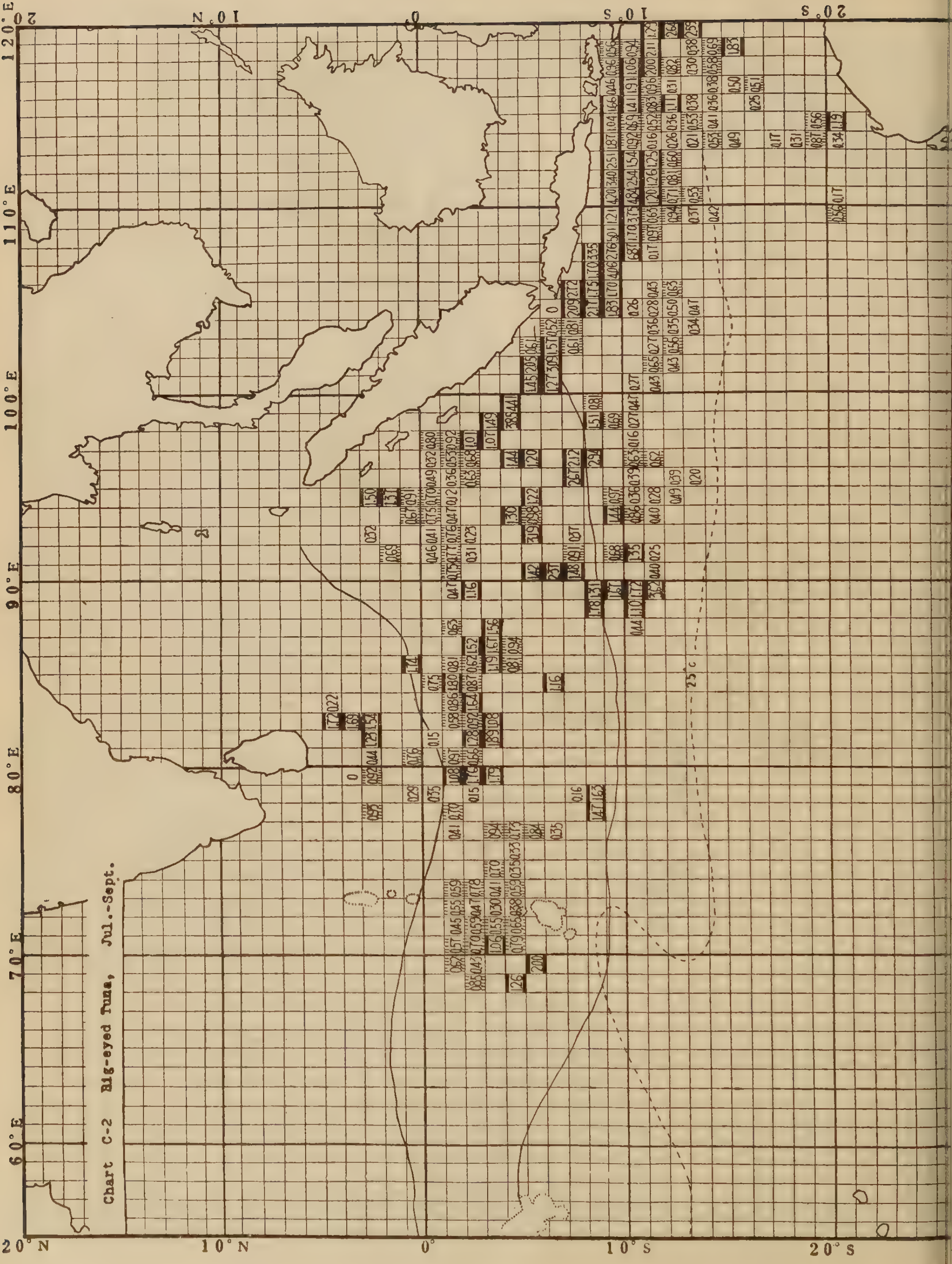
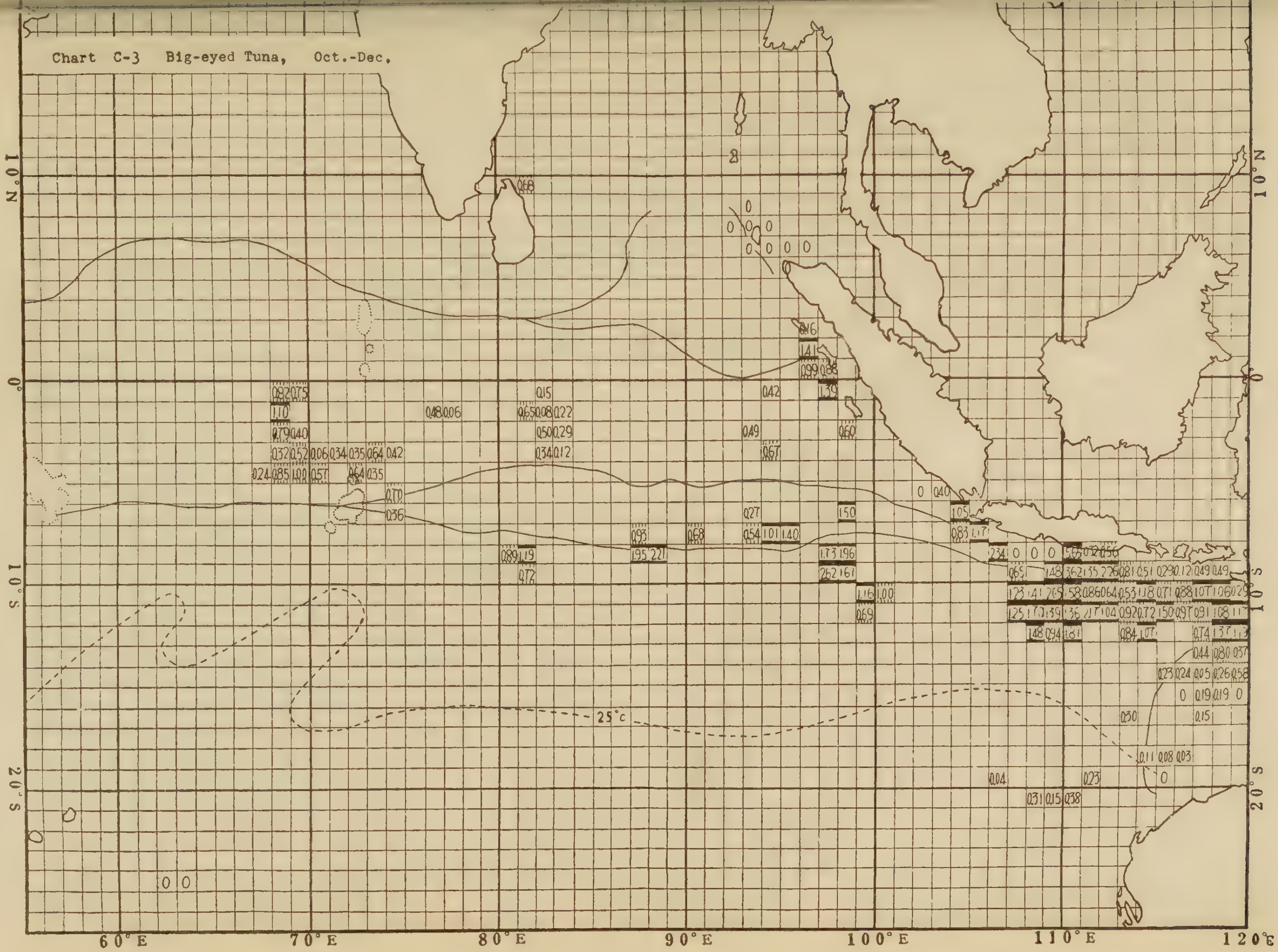


Chart C-2 Big-eyed Tuna, Jul.-Sept.

120° E
110° E
100° E
90° E
80° E
70° E
60° E
20° N
10° N
0°
10° S
20° S
25° c

Chart C-3 Big-eyed Tuna, Oct.-Dec.


10°N
0°
10°S
20°S
60°E
70°E
80°E
90°E
100°E
110°E
120°E
25°c

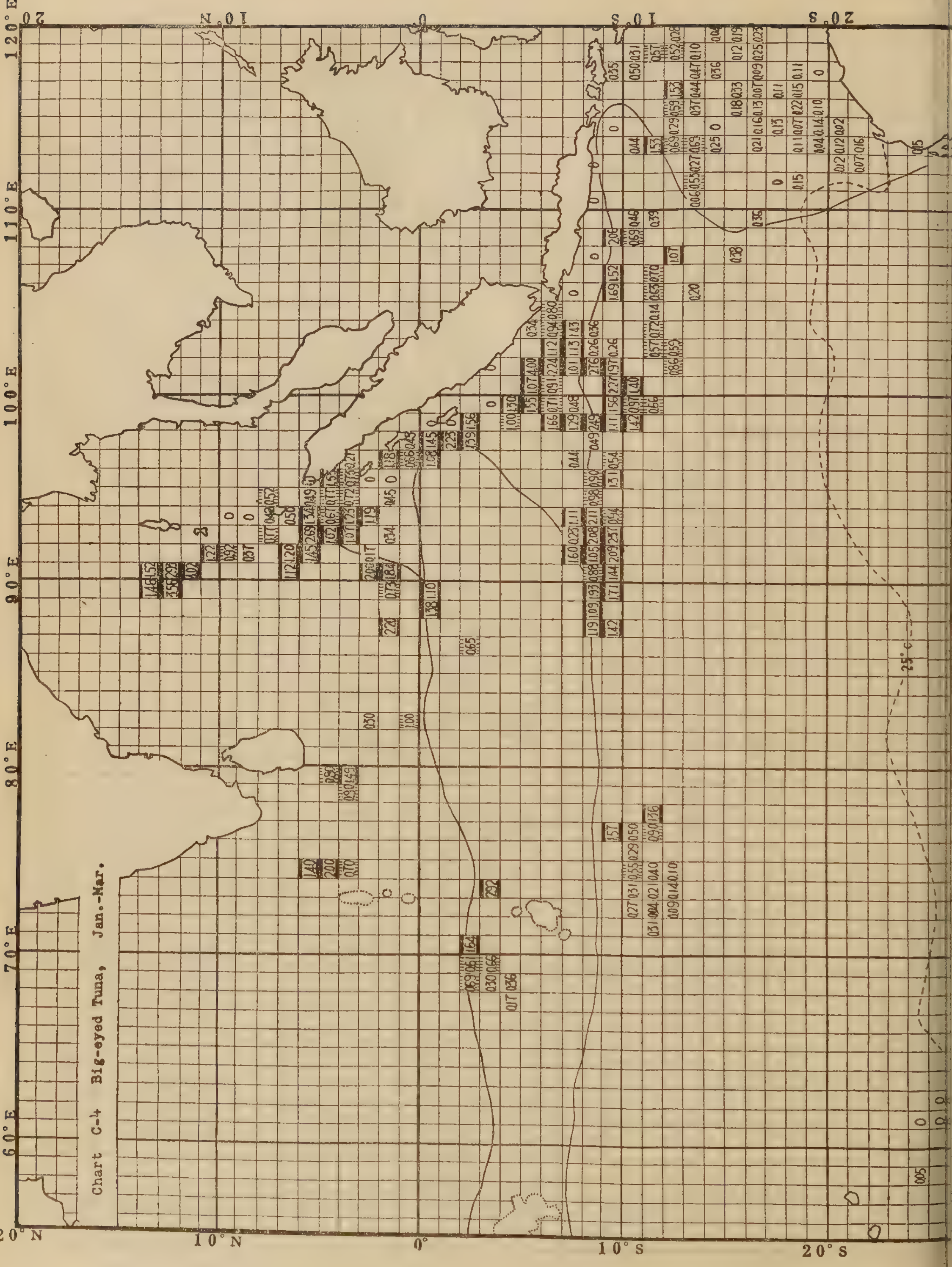


Chart C-4 Big-eyed Tuna, Jan.-Mar.
120°E
110°E
100°E
90°E
80°E
70°E
60°E
20°N
10°N
0°
10°S
20°S
25°C

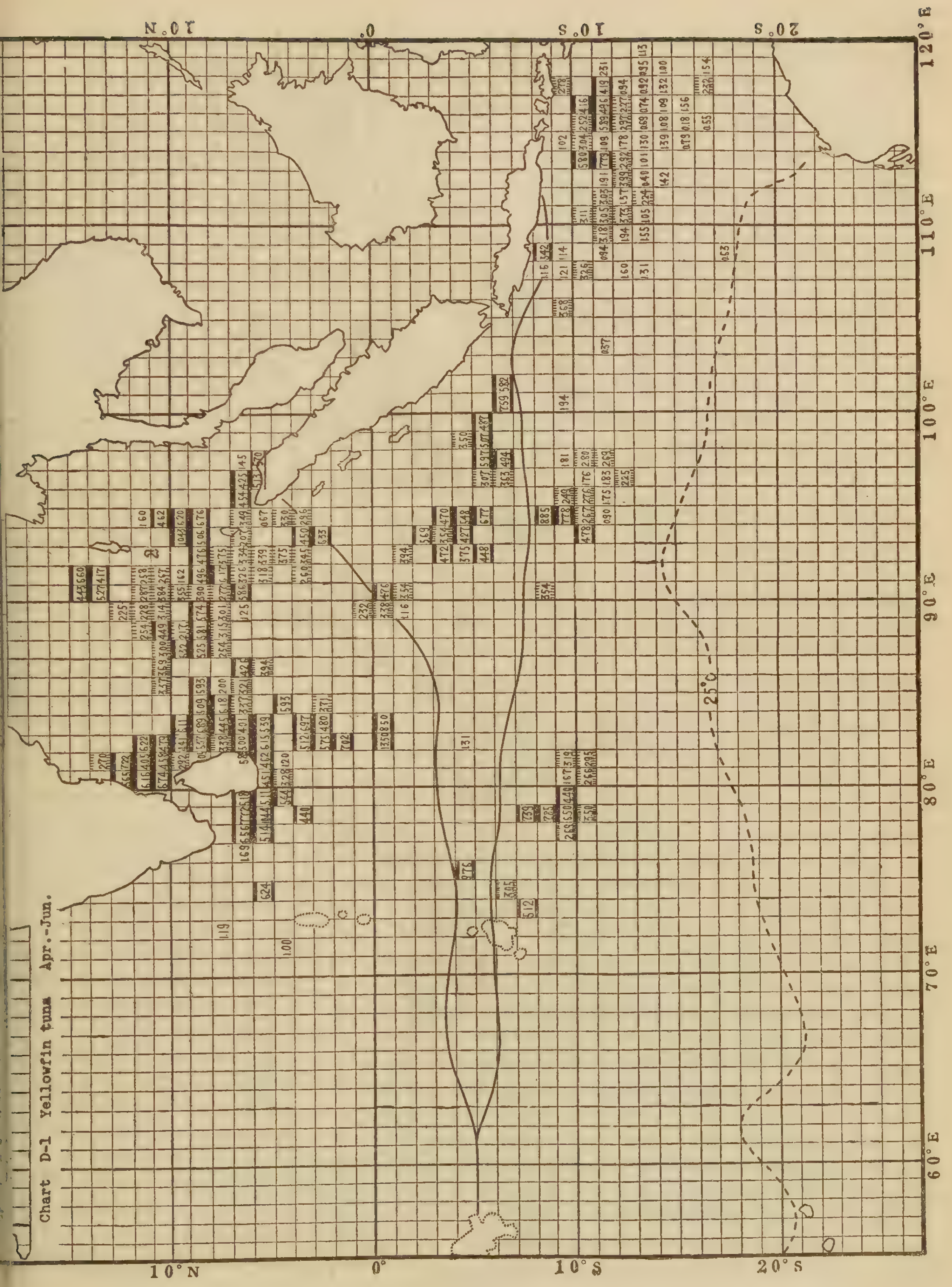

10°N
0°
10°S
20°S
120°E
110°E
100°E
90°E
80°E
70°E
60°E
25°C

Chart D-1 Yellowfin tuna Apr.-Jun.

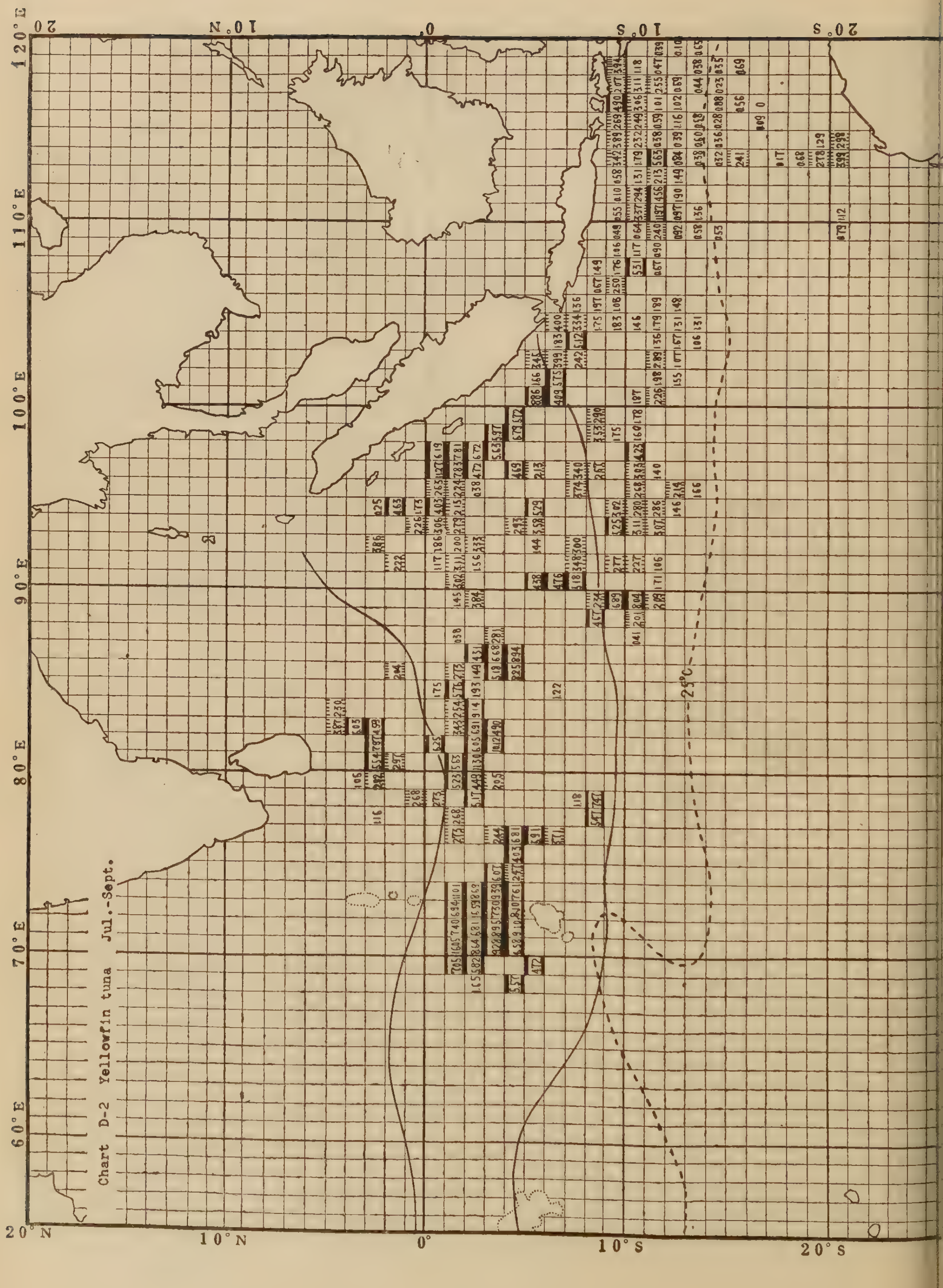


Chart D-2 Yellowfin tuna Jul.-Sept.

20°N
10°N
0°
10°S
20°S
60°E
70°E
80°E
90°E
100°E
110°E
120°E
25°C

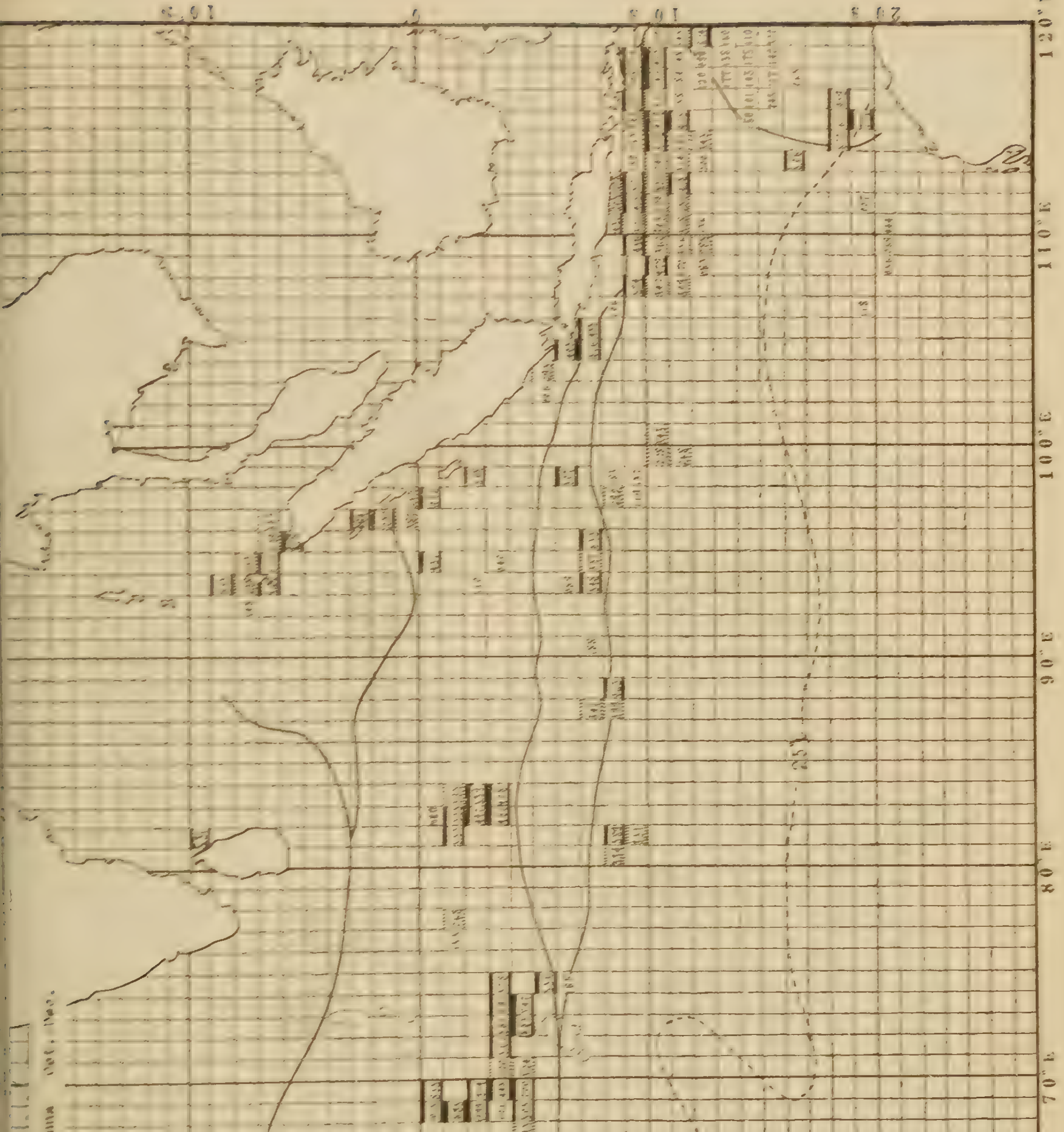


Chart D-3 Yellowfin tuna Oct.-Dec.

10°N
0°
10°S
20°S
120°E
110°E
100°E
90°E
80°E
70°E
60°E
25

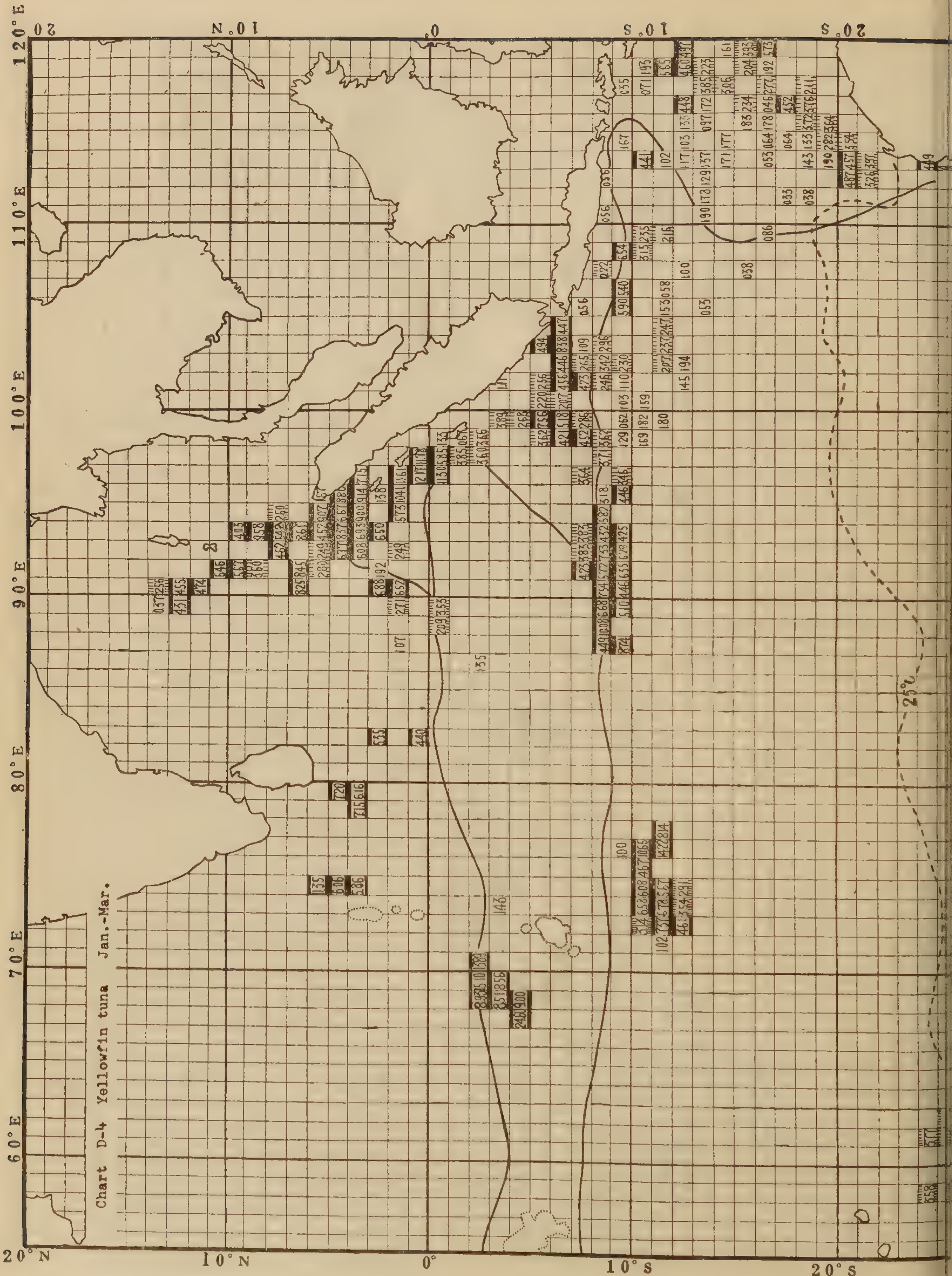

20°N
10°N
0°
10°S
20°S
120°E
110°E
100°E
90°E
80°E
70°E
60°E
25°C

Chart D-4 Yellowfin tuna Jan.-Mar.

9

SHOALING TENDENCY IN TUNA OBSERVED IN THE GREAT SUNDA ARCHIPELAGO

by

H. Maeda*

hing by long-line, which is still the most fishing method for tuna**, was prevalent Japan, although prior to 1880 or there- rea of operation had not extended beyond rom the coast. However the application rnal combustion engine to fishing boats a great advance in the fishing system and he area covered. To-day, however far ground may be, fishermen will go there considerably long time for a round trip, ble to obtain better catches. The fishing us extend from year to year.

the oceanic training cruises of the *Maru*, the training ship of the Shimonoseki the waters near the Great Sunda during the period from December 1953 y 1954, I endeavored to find some clues her tuna form shoals, and if so, how the ng tendency and the rate of exploitation ted; for these two problems seemed le for the estimation of the population tuna and also for the evaluation of the nds and the long range effect of fishing opulation. In this report, I shall take up, ary studies for the estimation of the oals; the question as to whether the of fishes and the composition of stomach hange horizontally and vertically, and e fishes form shoals. Some conclusions en on the relation between the rate of and the shoal-forming tendency.

YED AREA AND COMPOSITION HE LONG-LINE ASSOCIATION

ine of the fishing ground covering the re the long-lines were set up is shown in ll fishes caught by the same long-line red to be swimming about at the same e same area and taking common bait. , all of these fishes may be regarded as an ecological unit which is called here ence an 'association'. The associations ers near the Great Sunda Archipelago consisted of the following animals in the respective fishing grounds:

(1) Near Great Nicobar I. (Stations 1 and 2)
Neothunnus albacora (Lowe)
Sharks
Makaira marlina Jordan & Hill
Xiphias gladius Linne

(2) Off the northern end of Sumatra (Station 3)
† *Neothunnus albacora* (Lowe)
Parathunnus obesus (Lowe)
† Sharks
Makaira marlina Jordan & Hill
Acinacea notha Bory et St., Vincent

(3) Near Nias I. (Stations 4-8).
† *Neothunnus albacora* (Lowe)
Parathunnus obesus (Lowe)
Thunnus alalunga (Bonnaterre)
Makaira marlina (Jordan & Hill)
Xiphias gladius (Linne)
Histiophorus orientalis (Temminck et Schlegel)
† Sharks
Lepidocylium flavo-brunneum (Smith)
Coryphaena sp.
Sphyraena picuda Bloch et Schneider

(4) South of Lombok I. (Stations 10-15)
† *Neothunnus albacora* (Lowe)
Parathunnus obesus (Lowe)
Thunnus thynnus (Linne)
Xiphias gladius (Linne)
Histiophorus orientalis (Temmink & Schleger)
† Some kinds of Sharks
Coryphaena sp.
Sphyraena picuda Bloch et Schneider
Alepisaurus borealis (Gill)
Serranus sp.

Abundant animals are marked with a †; *Thunnus thynnus* is called by Japanese fishermen 'Indian tuna'.

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* Shimonoseki College of Fisheries, Shimonoseki, Yamaguchi Ken, Japan.
** The word 'tuna' used hereafter indicates exclusively *Neothunnus*.

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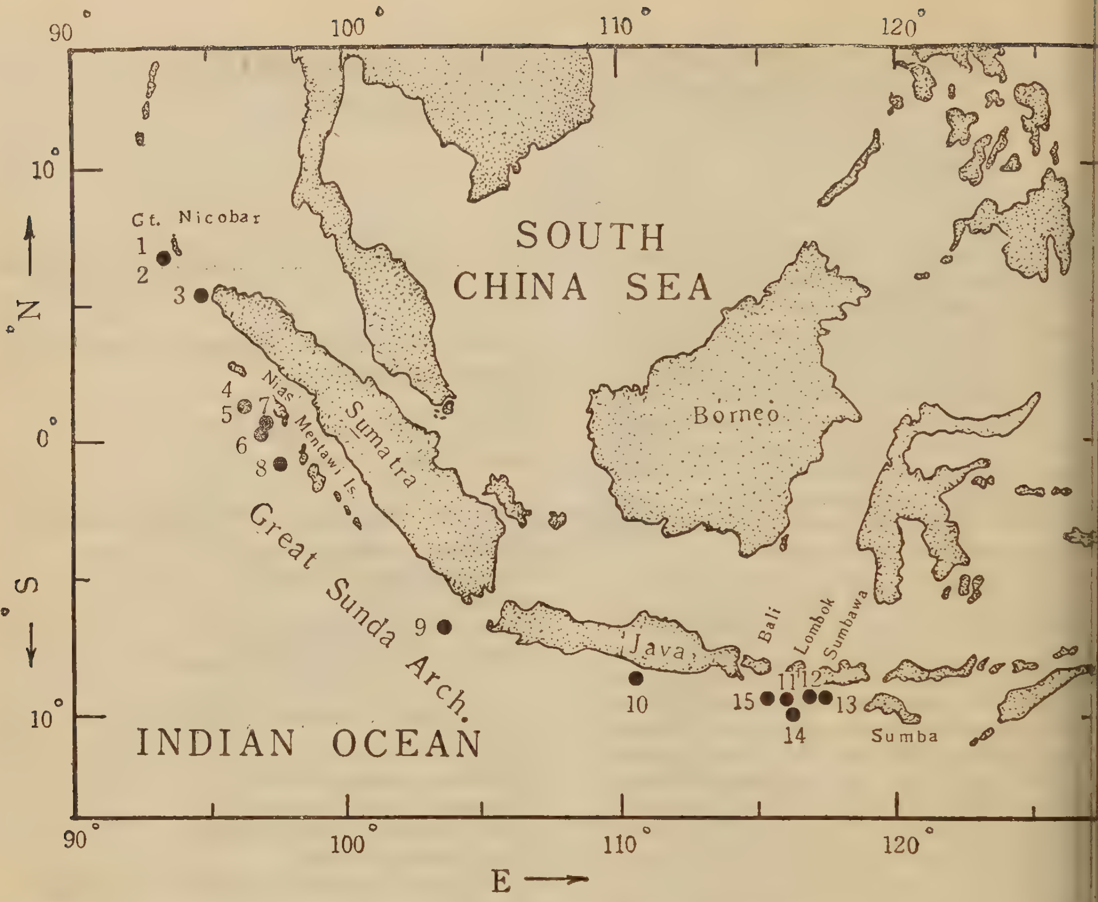
90°
100°
110°
120°
10°
0°
10°
N°
S°
E
Gt. Nicobar
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Nias
Mentawi Is.
Sumatra
SOUTH CHINA SEA
Borneo
Java
Bali
Lombok
Sumbawa
Sumba
Great Sunda Arch.
INDIAN OCEAN

Fig. 1. Chart showing Station Positions.

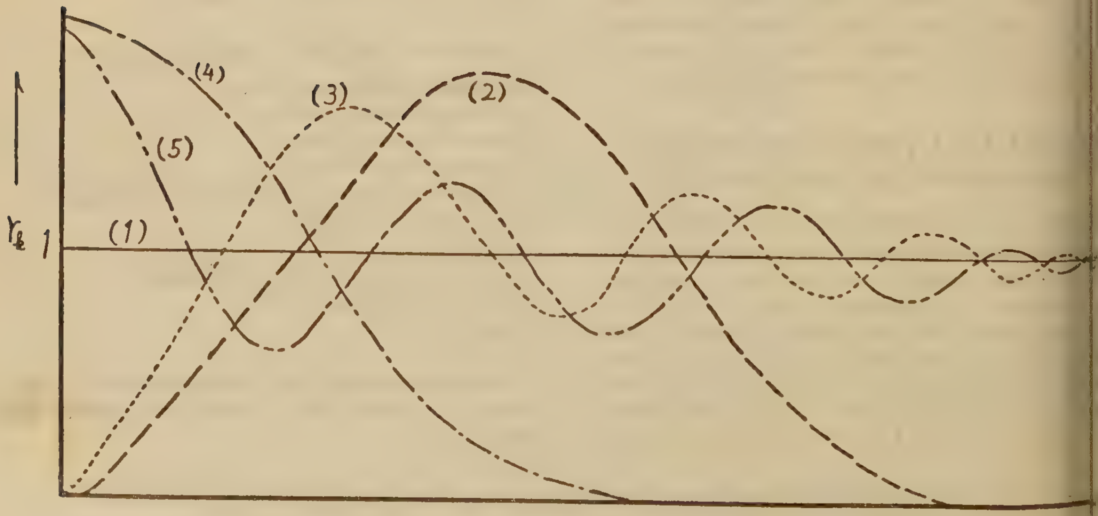

Fig. 2. $k-\gamma k$ relation diagram of each type of ideal shoals.

OOD HABITS OF TUNA AND SPEARFISHES

mpositions of the stomach contents of the shes are represented in Fig. 3(A)-1 to which the respective preys taken by each shown in wet weight. The food of *us* and other tuna consists mainly of ostly small file fishes and bramiform fishes rtly of crustaceans, most of which are ms such as Erichthus and Megalopa of like *Metapenaeus*. The spearfishes take rger fishes such as skipjacks and large id fishes and only a small amount of ns. The figures show that the main food *unnus*, the most abundant fish in the area, differs in accordance with the fishing

ICAL DISTRIBUTION OF FISHES

long-line gear the main line is longer than ge flag interval, consequently all hooks are eans situated at the same depth, but are l at several levels. Yoshihara (1954) made ervations on the depth of the hooks of such ne gear under the supposition that the the main line is catenarian and discussed on between the situation of hooks and the f fishes actually caught by the hooks, lead- e conclusion that the rate of exploitation ery sharply according to the relative depth Therefore, it is necessary, before the l distribution of fishes is discussed, to whether in the present cases the rate of on changes significantly in accordance relative depth of hooks. Each basket of in the present study contained 5 hooks, . 1 and 5 being situated at about 60 m., d 4 at about 80 m., and No. 3 at about The number of fishes actually caught by ctive hooks seems superficially to differ ance with their relative depth, although rences in the exploitation rate are doubtful, he exploitation rate at each hook is very n order to obtain more information, the experiment was carried out.

oks were divided into five groups in order. it is usual in such cases to divide the hooks groups, the degree of freedom is too small sected case, about a half of that obtained ided into five groups. Thus, the homo- the orders of hooks in respect of the ratios *unnus* : sharks : spearfishes : other fishes : and (*b*) *Neothunnus*: remainders, was It was found that the composition of association did not differ vertically, neither did the exploitation rate differ in accordance with the order of the hooks and consequently with depth.

VERTICAL DIFFERENCE IN THE COMPOSITION OF STOMACH CONTENTS

Although the exploitation rate did not differ with depth, it is still uncertain whether the stomach contents of tuna caught in different layers would differ from one another. To determine if the differences in the composition of stomach contents between some groups of fishes are significant or not, it must be examined whether the interclass differences of the z-transformed values of the weight percentages of respective prey organisms taken by respective individuals are significant or not, as compared with the intraclass differences of the same values. We can learn, by this method, whether the quantitative differences in each type of prey organisms are significant or not, but we are not yet able to reach the conclusion about the stomach contents as a whole, when the results of the examination of the respective prey organisms are not alike.

To make good this deficiency, I adopted for trial, as a simple method treating the stomach contents as a whole, the z-transformed values of the correlation coefficients between the composition of stomach contents of the first individual and those of respective ones of other individuals, instead of the weight percentages of respective prey organisms. In this case, the vertical differences in the stomach contents are regarded as significant, if the correlation coefficients between the compositions of stomach contents of the first individual and those of the fishes caught by hooks kept in the depth where the first individual was caught are significantly higher than the coefficients between the first individual and the fishes caught by hooks situated in different layers, namely when the stomach contents of the fishes caught at the same depth are similar to one another more significantly than those of the fishes caught from the different layers. The results of the analysis of variances are shown in Table III. It is assumed that, as the null hypothesis, the average value of the coefficients calculated between the individuals caught in the same layer is the same as that obtained between the individuals caught from the different layers. F_0- values are far smaller in all cases than the corresponding values shown in the F-table. Consequently, it is not necessary to estimate more accurately all correlation co-efficients reciprocally to deduce the conclusion.

From the results of the above-mentioned method, it may safely be said that the compositions of stomach contents of tuna do not differ in accordance with the relative depth where fishes are caught.

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* Available at the Indo-Pacific Fisheries Council Secretariat.

Relations between the number of Sharks and the number of Tunas in the same horizontal plane and between the former and the damage rate of Tuna by Sharks

When I considered in my previous paper (1953) the horizontal relations between the habitats of several sorts of salmons which have no predatory relation to one another, I used the correlation coefficient between the individual numbers of respective species caught in each section of the net in each haul. But in the present case, a conspicuous predatory relation is observable between tunas and sharks. The latter attacks the former. Consequently, it is possible that the distribution of sharks is alterable by the distribution of tuna and *vice versa* and that the proportion of damaged individuals to the total individual number of tuna may differ in accordance with the distribution of sharks. Therefore, I computed, as in the case of the salmon gill-net, the correlation coefficients between the number of sharks and that of tunas caught in 3, 4 and 5 baskets of the long-line, which were used as the unit length. The results are shown in Table IV, in which most values are slightly negative, but cannot be regarded as significant. Thus, tunas and sharks are considered to be distributed independently of each other and also the number of sharks and the individual number of damaged tuna or the damage rate to tuna by sharks, are independent of each other.

It was concluded that the distribution of sharks is not dependent on the distribution of tuna and the damage rate of tuna by sharks does not necessarily reflect the distribution of sharks.

The relation between the composition of stomach contents and the horizontal distance between the positions where Tunas were caught.

Although I have reported above that the composition of stomach contents does not differ with the relative depth where the fishes were caught, it is necessary to pay some attention to the relation between the composition of stomach contents and the distance between the positions on the long-line, where respective individuals are caught, as a preliminary step to estimating the size of shoals. For the examination of this problem, I used for convenience the same method as in the case of the vertical distribution of the stomach contents. Thus I examined whether the regression coefficient of the z-transformed values of the correlation coefficients between the composition of stomach contents of the first individual and those of respective ones of other fishes, to the distance between the first individual and respective ones of other fishes, is significant or not. Thus, I examined whether the composition of the stomach contents differs according to the distance between fishes or not, though it
known what components increase or decrea
one end of the long-line towards the oth
The results of the examination are shown in T

The distance of the hooks and the natur
composition of the stomach contents were f
be independent of each other.

ANALYSIS OF THE DISTRIBUTION IN

Although the different hooks are not situa
layer of exactly the same depth, it would seen
the present case to consider the data irrespe
the difference in depth ; because neither the
exploitation nor the composition of the
contents differed with depth. As the usual
for determinating the statistical distribution
quencies do not take into account the special
among the numbers of individuals caught by
tive units of gear, it is necessary to exam
distribution in space, before we consider th
tical distribution type of frequencies.
employed Morisita's second method for the
of distribution in space in the case of the
distribution on the gill-net. His first me
applicable when the exact position of each in
is known and the points capable of being
by individuals are continuous, while his
method is suitable in cases where the points
of being occupied by individuals are distrib
regular intervals and the number of ind
obtainable at each point may vary widely.
case of the long-line, the points capable
occupied by individuals are distributed at
intervals, but the point $z\,(n + 1)$ in order f
first hook are hypothetical ones incapable
occupied by any individual (here, n is the nu
hooks in one basket, z is 0, 1, 2 . . . . . . and th
length of $n + 1$ is about 250 m). Besides,
one individual may be caught at each poin
the reasons mentioned above, it is proposed t
lish a new formula under such a peculiar c
(unit length under consideration is the mean
of hooks).

$$P_{(k)} = \frac{N - k - 2(m - a) + (m - b}{\frac{m\,n\,(m\,n - 1)}{2}}$$

Here m = number of baskets used in
tive operations.
n = number of hooks in one bas

$$N = m(n + 1) + 1,\ \frac{k}{n + 1} = a > \frac{k}{n + 1}$$

$$b = \frac{k}{n + 1}.$$

probability of occurrence of other indivi-
he point k in order from a certain point
by an individual.
be a regular number.

lue b must be treated as zero when this
t a regular number. As actually observed,
ing value is obtainable :

$$P(k) = \frac{X_k}{\frac{T(T-1)}{2}}$$

is the total number of fish caught. X_k
nber of pairs of fish at the interval of k.
following value is used more conveniently,
distribution in space is considered :

$$\gamma_k = \frac{p(k)}{P(k)}$$

fishes are distributed at random, r always
(represented by type 1 in Fig. 2). When
single but self-spaced shoal it is indi-
ype 3. When there is a single continuous
shown by type 4, while it is represented
when there are many continuous shoals.

1) to (8)* show the values of γ_k actually
and Fig. 5 (10) to (14)* represent the
bserved values of X_k in the cases when the
ber of caught fishes is far less than in the
esented in Fig. 4(1) to (8) and p(k) is
l to include considerably accidental errors,
lues of X_k are mostly one or two.)

concluded that the distribution of fishes
n most cases to be rather at random,
t is somewhat difficult to obtain definite
s from these figures—especially from
) to (14), because most of the values of
y observed are very few and consequently
errors are very likely.

TRIBUTION TYPE OF FREQUENCIES INDIVIDUAL NUMBERS OF FISHES BY GEARS OF 1, 2 AND 3 BASKETS

een shown above that the rate of exploi-
s not vary with the depth of the hooks,
umbers of tunas and sharks caught in each
e gear are independent of each other, and
istribution of tuna does not exhibit any
continuity. It may, therefore, be pos-
btain the approximate distribution of
of the individual numbers caught by
2 and 3 baskets by the following process :
probability of exploitation at each hook
mn and the probability of unexploitation as $q = (1—p)$, then the random samplings of n, $2n$ and $3n$ are tried (here, n is the number of hooks in a basket). The frequency distribution, with which N individuals may be caught by gear of one basket is given by the following equation :

$$P_N = n\,C_N\, p^N q^{n-N}$$

The actually observed frequencies and the estimated ones of individual numbers obtainable by gears of 1, 2 and 3 baskets which are used respectively as the unit length of the long-line under consideration are shown in Fig. 6 (1)-1 to (14)-3.*

Comparing the actually observed distribution of frequencies and the estimated one with each other, it is found these are not so different from each other in cases when the p values are not large, but as the p value increases the difference between the actually observed distribution of frequencies and the estimated one grows rather conspicuously and the former begins to show a slight continuity.

THE RELATION BETWEEN THE RATE OF EXPLOITATION AND THE DIFFERENCE OF THE OBSERVED DISTRIBUTION OF FREQUENCIES FROM THE RANDOM DISTRIBUTION

The conclusion of the previous section led to attention being paid to the relation between the rate of the exploitation and the difference of the observed distribution of frequencies from the estimated distribution. For the analysis of the above-mentioned relation the whole or each term of the frequencies must be taken up. However, it is very difficult to treat the distribution as a whole and also it is confusing to attempt to deduce the conclusion for the distribution as a whole by taking each term into consideration. So, I treated only the O-term this time and used the value (d)—observed frequency / estimated one—of the O-term as an index of the distortion. This value may be regarded as an abbreviated index of continuity, although it is more or less uncertain, in such cases when all of the terms are only of the weakly continuous type. To ascertain whether d changes in accordance with p, the rate of exploitation, I examined whether the regression coefficient of d on p *is* significant ; the results obtained are shown in Table VIII. The shoaling tendency of fishes is higher in the area where the exploitation rate is higher.

So far as the rate of exploitation observed in the present study is concerned, the shoaling tendency varied with the rate of exploitation, although the rate was not high.

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* Available at the Indo-Pacific Fisheries Council Secretariat.

SUMMARY

1. Observations regarding the shoaling of tuna and the relation between the rate of exploitation and the shoaling tendency are discussed on the basis of data obtained during December 1953 to February 1954 in the waters near the Great Sunda Archipelago.

2. The outline of the fishing grounds and the composition of the catches made by the tuna long-line are furnished.

3. The Compositions of the stomach contents of the chief fishes is given.

4. Vertical differences in the ratio, *Neothunnus* : sharks : spearfishes : other fishes : naught, and of the rate of exploitation of tuna are found to be of no significance.

5. The composition of the stomach contents of tuna and the depths from which they are caught have no relation.

6. Tuna and sharks are distributed independently of each other and the damage rate of tuna by sharks is also independent of the number of sharks.

7. Horizontal distance between individuals of tuna caught and the nature of the stomach contents are independent of each other.

8. With the help of a new formula, distribution of tuna in space is shown to be mostly at random in the present cases.

9. The distribution of tuna does not differ much from Bernoulli's distribution, when the exploitation rate is not high, while a difference between the observed distribution and Bernoulli's distribution increases with an increase in the rate of exploitation with which is also associated a rather continuous distribution.

10. The shoal forming inclination changes in accordance with the rate of exploitation within the range of moderate exploitation studied.

Acknowledgement.—I must express my sincere thanks to Prof. K. Tanaka, President of Shimonoseki College of Fisheries, Prof. D. Miyadi of Kyoto University and Prof. I. Matsui of our college for their kind guidance and criticisms given to my work. And also I am very grateful to Dr. M. Morisita of Kyushu University for teaching me statistical methods, Dr. T. Tokioka of Seto Marine Biological Laboratory for reading manuscript, Dr. T. Abe of Tokai Regional Fisheries Laboratory for identifying bait-fishes and to Dr. S. Miyake of Kyushu University for identifying crustaceans found in stomach contents. My hearty tha due to Capt. K. Komano and all other crew *Shunkotsu-Maru*, who helped me extensively the cruises.

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TABLE I

Date, number of tuna caught and gear used at eac

St.	Date	No. of gear	Total c tur
1	Dec. 26, '53	60	
2	27	56[1]	
3	29	80	
4	31	61	
5	Jan. 2, '54	60	
6	3	80	
7	4	80	
8	5	80	
9	8	40	
10	16	80	
11	18	80	
12	19	80	
13	20	100	
14	21	80	
15	22	80	

Note :—Position of each station is shown in

(1) : The total number of gear used operation was 60, of which th were omitted, because they were and the accurate position of th was not clear.

(2) : Damaged individuals are included

TABLE II

xample of actually observed ratio, Neothunnus: *sharks : spearfishes : nought, in each order of hooks* (*St.* 2)

Order hook	1	2	3	4	5	Total
.. ..	11	14	14	12	13	64
.. ..	5	8	13	17	10	53
.. ..	0	1	0	0	1	2
.. ..	0	0	0	0	0	0
.. ..	40	33	29	37	32	171

TABLE III

of the examinations of the equality of the mean values of similarities of the composition of stomach contents of fishes caught in different layers.

No. of observed individuals in respective layers					F_0	n_1	n_2	$F^{n_1}_{n_2}$ (0.05)
ower-2	Shallower-1	f.1.	Deeper-1	Deeper-2				
3	4	2			0.07	2	6	5.14
5	6	2			0.23	2	10	4.10
		11	10	2	1.24	2	20	3.49
2	10	8			0.17	2	27	3.35
	8	8	1		0.21	2	14	3.74
		5	7	2	0.20	2	11	3.98
		5	4	2	0.57	2	8	4.46
	5	6	0		1.19	1	9	5.12
		3	4	1	1.09	2	5	5.79
5	2	3			2.34	2	7	4.74

e stations where the samples of stomach re too scarce are not included.

he numbers in this column show the individuals caught in the layer where the first individual was caught. The number of samples obtained from a little shallower or deeper layer than the f.1. (fixed layer) is shown in the column of shallower-1 or deeper-1 and that from much more shallow or deep layer is given in the column of shallower-2 or deeper-2.

TABLE IV

Correlation coefficients between the number of sharks and that of tunas and between the former and the damage rate of tuna by sharks in 3, 4 and 5 baskets of gears.

St.	No. of gear under consideration	Correlation coefficients		
		T-S	D-S	Dr. - S
1	3	- 0.43	- 0.48	0.05
	4	- 0.59	- 0.60	0.45
	5	- 0.53	- 0.52	0.32
2	3	- 0.04	0.19	0.46
	4	- 0.08	0.33	0.72x
	5	- 0.01	0.15	0.23
7	3	0.11		
	4	- 0.07		
	5	- 0.02		
10	3	- 0.30		
	4	- 0.28		
	5	- 0.13		
11	3	0.23		
	4	0.11		
	5	0.34		
12	3	- 0.09		
	4	- 0.20		
	5	- 0.10		

Note:—The values, not shown in this table, are excluded because the number of tuna or shark was too small in those areas. The values with asterisk are regarded to be significant at 0.05 level of significance.

T: *Neothunnus*, S: sharks D: damaged individuals of *Neothunnus* Dr.: damage rate of *Neothunnus* by sharks.

TABLE V

Results of the examination on the regression coeffi
z-transformed values of the correlation coefficien
the composition of stomach contents of the first i
and those of the subsequent ones, on the distanc
the first and the subsequent individuals

St.	F	n_1	n_2
1	0.41	1	7
2	0.06	1	11
3	1.58	1	21
4	1.23	1	28
5	0.18	1	15
6	0.11	1	12
7	0.92	1	9
8	2.52	1	9
11	0.15	1	6
12	6.41*	1	8
14	3.42	1	8

Note:—The cases not shown in this
omitted since they were very few. The
asterisk is regarded to be significant at 0.0
significance.

TABLE VI

Results of the examination whether the regression coefficient of d *on* p *is significant*

Unit of gear under consideration	n_1	n_2	F_0	$F^{n_1}_{n_2}(0.05)$	A
1	1	11	5.73	4.84	0.98
2	1	10	11.90	4.96	1.45
3	1	10	9.95	4.96	0.38

Note: $d=A+Bp$

10

PLANKTON ASSOCIATIONS AROUND JAPAN

by

S. Motoda*

e great warm current, Kuroshiwo, after bath- the Pacific coast of the Japan Islands, eastward on meeting the polar front off the ern coast. The Tsushima Current which es from the Kuroshiwo and enters the Japan hrough the Tsushima Strait flows along the Sea coast and then sends an eastward branch he Pacific through the Tsugaru Strait and yet er branch into the Okhotsk Sea through the Strait.

cold current, Oyashiwo, flows from the north meeting the Kuroshiwo at the polar front, below the Kuroshiwo and continues south- in the subsurface layer. In the Japan Sea ld Liman Current occupies a wide area off the ime Provinces making a discontinuous border surface with the Tsushima Current. There deep cold waters that have not mixed with ass of shallow waters in the Japan Sea.

above patterns of ocean currents have resulted emarkable complexity of geographical distri- of oceanic species of plankton which are orted to regions where they cannot normally luce. The production of neritic plankton is uch influenced by the influx of the offshore ts which affect not only temperature con- but possibly also the supply of stimulating nces for the germination and reproduction of plankton.

the Pacific coasts facing the Oyashiwo the s in general are abundant during the succes- easons from spring to autumn, though their ers fluctuate. On the southern coasts bathed Kuroshiwo the season of maximum growth oms is from summer to autumn, though many exceptions occur; a summer outburst of lankton is often met with in the inshore of certain localities. In the offshore Pacific, on samplings have been made at two points are fixed for meteorological observations. At rthern point, 39°N 153°E, two maxima of increase, one in June and the other in ber, are observed, while at the southern 29°N 135°E, only one maximum is observed ruary to May. On the Japan Sea coasts the al fluctuation of diatoms production is generally shown by a bimodal curve; that is, spring and autumn growths are observed, and these two maxima have a tendency to converge in higher latitudes.

The major groups of diatoms responsible for the maximum increase vary with localities as well as with seasons. They are composed mainly of sub-arctic or north temperate species on the northern coasts, while they are mainly south temperate species on the southern coasts. For instance, the diatom increase on the Pacific side of north Hokkaido usually begins in March with an outburst of growth of a winter species, *Biddulphia aurita*, which is successively replaced by temperate species with the progress of the seasons. On the southern coasts, the primary outburst is represented by temperate species and hence the beginning of growth is not always earlier than on the northern coasts.

The oceanic species (whether preferring warm water or cold water) are often used as indicators of the nature and range of ocean currents, and so their appearance in the coastal waters is of great significance in determining what happens in the sea by reference to the plankton calendar of normal years. Many tropical and subtropical species of plankton are transported by the Kuroshiwo to the far north, and they also migrate into the Japan Sea via the Tsushima Current, although the latter having received some admixture from the coastal waters and the waters of Liman Current during the flow off the Japan coasts, contains a proportion of neritic and cold water plankton, and essentially the same plankton associations are found in the Tsushima Current as in the Kuroshiwo.

Thus, the Tsushima Current off the coasts of Japan Proper carries with it clear biological indicators, in the form of tropical and subtropical plankton so far as the summer and late autumn are concerned, and *Rhizosolenia styliformis* var. *latissima*, *Climacodium biconcavum*, *Ceratium trichoceros*, *C. deflexum* etc. are used to gauge the range of this Current. Some of them are often as concentrated as to make a homogenous association. The tropical blue green algae, *Trichodesmium contortum* and *T. erythraeum* are also found within the range of Tsushima Current.

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* *Faculty of Fisheries, Hokkaido University, Hakodate, Japan.*

Some of these tropical and subtropical immigrants of the Tsushima Current appear on the northern coasts as far as the Tsugaru Strait or beyond in the autumn season. The representative species of immigrants of three major groups, diatoms, dinoflagellates and copepods, which appear on the northern coasts in autumn, have been reported as follows: *Chaetoceros coarctatus*, *Ch. diversus*, *Ch. anastomosans*, *Ch. costatus*, *Ch. messanensis*, *Ch. pseudocurvisetus*. *Bacteriastrum comosum* var. *hispida*, *Cerataulina Bergonii*, *Coscinodiscus granii*, *Climacodium biconcavum*, *C. Flauenfeldianum*, *Guinardia flaccida*, *Hemiaulus indicus*, *Rhizosolinia cylindrus*, *R. acuminata*, *R. castracanei*, *Ceratium deflexum*, *C. trichoceros*, *C. inflexum*, *C. candelabrum* var. *dilatatum*, *C. carriense*, *C. contortum*, *C. gibberum*, *C. molle*, *Calocalanus plumulosus*, *C. pavo*, *C. styliremis*, *Paracalanus aculeatus*, *Acartia erythrea*, *Aetidius giesbrechti*, *Labidocera acuta*, *Temora stylifera*, *Sapphirina nigromaculata*, *Copilia mirabilis*, *Corycaeus curtus*, *C. rostratus* and some others.

The time of appearance and disappearance of these immigrants as well as their numbers on the northern coasts vary from year to year and these variations reflect the strength of the Tsushima Current. These tropical and subtropical species are quite absent in the northern regions from winter to summer. This fact suggests that there is a prevailing influx of the Tsushima Current into the Japan Sea during the summer, and that these immigrants drift for about two months until they appear on the northern coasts. Physical observations have proved that the influx of the Tsushima Current passing through the Tsushima Strait is very weak during the cold season.

The Liman Current may be indicated by the oceanic species preferring cold water. The most characteristic and useful species are *Chaetoceros atlanticus*, *Ch. convolutus*, *Ch. concavicornis*, *Ceratium arcticum*, *C. longipes*, *Ptychocylis obtusa*, *Calanus cristatus*, *C. plumchrus*, *Eucalanus bungii bungii*, *Sagitta elegans*, *Oikopleura labradoriensis* and so forth. There is a clear demarcation of the distribution area between the above boreal species and the subtropical species in the waters off the coast of Japan proper, but this demarcation becomes vague off the west coast of Hokkaido, in which more mixed water is found.

In the deep waters of the Japan Sea adult *Calanus cristatus* and *C. plumchrus*, *Gaetanus armiger*, *Bradydius armata*, *Gaidius brevispinus*, *Euchaeta japonica*, *Primno macropa* and others are known to be characteristic.

A tributary current of the Tsushima Current entering into the Okhotsk Sea maintains the same plankton associations as in waters off the west coast of Hokkaido in the Japan Sea during the season. The offshore waters of the Okhots are cold in nature and the plankton associatio composed of *Chaetoceros atlanticus*, *Ch. conv* *Thalassiothrix longissima* and other cold species. The waters of the Oyashiwo are si characterized by abundant cold water faun flora as represented by *Calanus cristatus*, *C. plum* *Eucalanus bungii bungii*, *Sagitta elegans*, *Ptyc* *obtusa*, *Ceratium arcticum*, *C. longipes*, *Chae* *atlanticus*, *Ch. convolutus*, *Corethron h* *Thalassiothrix longissima* and many other for

In the Kuroshiwo, as in the Tsushima Cu the number of tropical and subtropical pl have a tendency to increase during the warm s However, such tropical and subtropical spec *Chaetoceros coarctatus*, *Ch. dadayi*, *Ch. peru* *Climacodium biconcavum*, *Gossleriella tropica*, *Gui* *flaccida*, *Rhizosolenia styliformis*, *Trichode* *Thiebauti* and many others appear even in mingled with cold water species, far toward the front off the northern coast of Japan proper.

Mention will be made of certain species are noteworthy for their abundance and for value as food for migrating fish. Unfortu notwithstanding their ubiquity and impo from the viewpoint of human economy, the identity of some plankton species has not ye ascertained.

A copepod, *Calanus plumchrus* Marukaw valued highly as forming an important part zooplankton in Japanese waters. He mackerels, salmon and many other fish subsist it. It is widely and abundantly distributed cold waters, but the individuals occurring shallow layers are those which have not yet dev to maturity. Adults are only found in deep at least from below 300 metres, or collected the stomach contents of such fish as Alaska p The young *C. plumchrus* appears very freq in spring in the shallow layers on the west of Hokkaido, and that they are supposed to to the surface in that particular season of the

C. plumchrus is closely allied to *Calanus* Brady and while some authors consider that th species are identical, according to Nakai, the be clearly distinguished in that spines are on the distal inner margin of the second basip of the swimming feet of *C. plumchrus*, whic be characteristic of vast areas in the higher lat of the Pacific from the Japan Islands to the Am continent; it is replaced by *C. tonsus* in the so warm waters.

Calanus cristatus Kroyer is also a significant s in the northern waters. Although it is less abu

C. *plumchrus* around Japan, its larger size t an important role in the production of the Having a life cycle closely resembling that *plumchrus*, the adult forms of *C. cristatus* und only in deep layers and the individuals ed from the shallow layers are all in young . They are often found in the stomach ts of fish and of whalebone whales.

is widely known that, *Calanus finmarchicus* tutes a large portion not only of the marine ods but also of all marine zooplankton, in northern Atlantic. Another copepod, *C. ndicus* (Claus), closely allied to *C. finmarchicus*, of importance in the north Atlantic. However it has been suggested by Nakai, and confirmed arshall, that a species of copepod in Japanese that has long been described by many authors *. finmarchicus* or *C. helgolandicus* presents ological characters different from both. ugh this species is of some significance in ese waters it is not of such primary importance the Atlantic and in the seas about northern *C. plumchrus* is probably the most abundant.

hausia pacifica Hansen is also important in of its wide availability as food of fish and whales. ng the several species of euphausiids and mysids, *cifica* is the most prevalent. It forms at times e part of the zooplankton collected in the Japan s well as in the northern part of the North c. The stomachs of sei whales and finbacks t in the Pacific are often distended exclusively *E. pacifica*. On the other hand, whalebone s in the southern part of the North Pacific mainly on *Euphausia similis*, and in the Okhotsk Sea mainly on *Thysanoessa inermis*. According to Komaki the mature forms of *E. pacifica* migrate to the surface in large swarms on the coasts of Japan Sea in early spring. They fall prey to the herrings, mackerels and other fish that are just migrating in the region. They are also fished for human consumption.

Themisto sp., which has often been described by Japanese scientists as *Parathemisto oblivia* (Kroyer) is an exceedingly significant form in Japanese waters and Atka mackerel and other fishes are very fond of it. This species widely abounds around Japan, but it is replaced by *Parathemisto libellula* (Mandt) in the far northern Pacific. Bowman, after examining the specimens from Japanese waters, has identified it as *Parathemisto japonica* Bovallius, although Nakai maintains that *Themisto* sp. of the Japanese waters does not agree with the illustrations of *P. japonica* given by Bovallius.

A chaetognath, *Sagitta elegans* Verrill, is distributed frequently in the cold waters, and is valued as an important source of food for plankton feeding fish. A pteropod, *Limacina helicina helicina* (Phipps), is also found on many occasions distending the stomachs of salmon in these waters.

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11

FLUCTUATIONS IN THE DISTRIBUTION OF SARDINE DUE TO OCEANOGRAPHIC CONDITIONS IN THE FAR EAST

by

Z. Nakai*

Among the extraordinary changes in oceanographical or meteorological conditions which have occurred in the Far East region from time to time since 1923, a few, at least, are supposed to have had a remarkable influence upon the fisheries for the sardine, *Sardinops melanosticta*. For instance, the mortality on the North Korean coast in 1923 resulted in the discovery of the existence of tremendous resources of this fish, which eventually led to the industrial exploitation of the stock. More often, however, some of these phenomena are believed to have been responsible for interfering with the reproduction of the stock and thus to have contributed to the depletion of the catch. The present paper deals with the outline of these phenomena along with some additional information which has recently become available.

CASES OF PHENOMENAL MORTALITY AND THE CAUSES

During the days from 24th to 26th of October, 1923, enormous quantities of large-sized sardines were found dead or in a dying condition throughout the eastern coast of North Korea extending for more than 80 nautical miles from Gyotaishin (a fishing village west of Cape Kozakof) to Jokaishin (a village near to Tanchon), passing around Cape Boltin. So numerous were the dead fish that a great crowd of people gathered to collect them on the beach, day in and day out. On the basis of field interviews with the people, the total amount thus collected was estimated to be somewhere about 20 to 40 thousand metric tons, most of which was made into manure or fish oil.

In an attempt to arrive at a possible cause of the phenomenon, Nakai (1939) studied the surface temperature at the foot of Cape Boltin, the center of the occurrence, using data recorded at about 1000 hours every morning in the month of October for two decades from 1918 to 1937, along with other meteorological data. The summary of evidence from these and other records is as follows:

(1) During 12 days, October 9th to 20th, 1923, prior to the heavy mortality, the surface temperature in the area rose steadi 13.2°C to 14.3°C.

(2) On the nights of 20th and 23rd C centers of strong low pressure (7 and 754 mm.) traversed the area easterly direction. The stormy lasted till 24th.

(3) An abrupt decrease in the surface te ture to 6.8°C was noticed on followed by a fall in the atmo temperature next day, when the d began to be stranded.

(4) Except on the 24th, the atmo temperature was always higher th water temperature during ten day 22nd to 31st October.

(5) The surface temperature was 6.2 the 23rd, which was nearly 7°C than the average for October dur period 1918 to 1937. It persisted the range of 5.8 to 7.5°C until No 5th, the lowest ever recorded the 1918.

(7) The topography of the area forms a p tory with the bottom sloping to a depth of more than 1,000 located a few miles off-shore, encourages the development of upw of cold water from the lower layer

(7) The water temperature in the area months of April to October is lower than that of Chongjin (or S north of the area.

On the basis of these facts, Nakai postulat the abrupt decrease in the surface tempera the particular area was directly responsib physical disturbance of the fish resulting mass mortality; the primary cause of the d in water temperature was a violent upwel cold underlayers that occurred under the in of the deep depression passing over the are cold wave blown from the high pressure fo the low pressure was the subordinate cause.

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* Chief Biologist, Tokai Regional Fisheries Research Laboratory, Tokyo, Japan.

ituation was suggestive of an enormous sardines distributed along the eastern coast a, a fact which had not been suspected.

As a consequence, there was considerable development of the sardine fisheries in the area with the amount of catch increasing as shown in Table I.

TABLE 1

Five Year Totals of Sardine Catch in Korea, 1894-1942 (*Unit : Tens of thousands of metric tons*)

	1894-1922	1923-27	1928-32	1933-37	1938-42
ount	0	38	155	410	386

r cases of mortality but with quite contrary re known to have happened in other parts world. Several years after an abnormal of the sardine, *Sardinops caerulea*, which oerster (1941) reports to have occurred in inlet and Pender harbour in early January the sardine entirely disappeared off British a. According to Herdman (1923), count- ions of the tile-fish (*Lopholatilus chamoeleon-* ere found dead or moribund on the surface cean in the North American Gulf Stream he spring of 1882. The wholesale destruc- he fish is thought to have been caused by a ifting of the Gulf Stream and the Labrador most probably under the influence of furious gales and an unusual quantity of ice from tic region. It took more than 30 years he fish made their reappearance in the in 1915. It is interesting to note that, in with these cases, the mortality in the North gion served as a harbinger of fishery develop-

er case of serious mortality took place e coast of Hidaka District on the Pacific Hokkaido from November 12th to 14th, n a detailed report of the accident, Kuragami ana (1934) describe the beach at Monbetsu, Yerimo (or Erimo) Saki, as having been by innumerable corpses of medium-sized each measuring about 18 cm., forming .5 to 2 metres high, 1.5 metres wide, and han two nautical miles in length along the e. The amount of dead fish used for manure nated to have exceeded 3,000 metric tons. week earlier, similar occurrences but on a cale were reported from neighbourhoods Jrakawa, Horoizumi and Samani. Included usative factors were: a whole north-westerly ch blew at 26 m./s. on the 3rd and a west- terly wind at 24 to 30 m./s. on 6th to 8th mber; the tidal wave driving back the movement of the fish; a sudden drop of mperature due to an upwelling; tuna and grampus invading the area; increased inflow of fresh water after the heavy rainfalls; excessive concentration of the fish, bringing about a reduction in available oxygen; and fatal injuries incurred due to the congestion of the frantic fish.

Although the damage was limited in area and extent as compared with the North Korean occurrence, it is noteworthy that both had the following characteristics in common. The mortality in both cases occurred in association with a sudden drop of water temperature in the colder season at a locality close to the northern migratory limit, when and where the fish would usually leave for the southern migration; and the westerly deviated gales blew in succession immediately before the occurrences in the vicinity of the headlands where upwelling was liable to develop. At no time in history except during that year (1933) has the annual yield of sardine in Hokkaido been so great as 510,000 metric tons landed then and there.

At Saanich inlet the temperature of the surface zone ranged from 4.3 to 6.0°C, while the intermediate zone had temperatures varying from 7.5 to 9.5°C. However, the evidence available to Foerster did not permit him to ascribe the cause of the mortality to the coldness of the environment. Nevertheless, the fact that the occurrence was in the cold season and at the northern limit of the migration coincides with those reported in the Far East.

Other minor cases of sardine mortality due to oceanographic changes in this part of the world are omitted.

EFFECTS ON DISTRIBUTION AND MIGRATION

One of the most striking instances, in which an abnormal oceanographical condition had a direct influence upon the distribution and migration of sardine and on the general fishing situation, took place along the east coast of Korea during the spring and summer of 1936 (Nakai, 1949). In the Far East, the north-west monsoon is prevalent almost every winter, but the wind which blew on the east Korean coast from the middle of December, 1935, until the following March was so persistent and so unusual that abnormally low temperatures continued in the area from the beginning of 1936 until the late fall of that year. The surface temperatur in the season for the northerly migratio to August) of the large-size sardine in drif grounds within 20 miles offshore may be c in Tables II and III, the one being the avera corresponding months for the period 1929 the other for 1936.

TABLE II

Average Monthly Surface Temperature range on the East Korean Coast, April through August, 1929-1940 (*Degrees C*

Province	North Latitude on the Sea Coast	April	May	June	July	A
North Hamkyong	42°20′ — 40°35′	1-4°	5-7°	9-11°	15-17°	
Kangwon ..	39°02′ — 36°38′	6-10.5°	9-14°	13-17°	18-20°	
North Kyongsang	36°38′ — 35°39′	10-12°	13-15°	15-17°	18-21°	

TABLE III

Surface Temperature Range on the East Korean Coast, April through August, 1936 (*Degrees Centigrade*)

Province	April	May	June	July	A
North Hamkyong	1-3°	3-6°	8-10°	12-18°	
Kangwon	3-7°	7-12°	11-14°	13-19°	
North Kyongsang	7-10°	11-13°	12-16°	18-20°	

In 1936 the Fisheries Experiment Station of the Government-General of Chosen or Korea predicted in the oceanographical chart for March that the fishing season for sardine would occur later than usual because the temperature, compared with the normal year, was lower by 2 to 3°C in the a whole, and by 6 to 7°C in certain zones. expected, the fishing season was delayed, an ingly the situation of the drift netting indu remarkably affected as is seen in Table IV.

TABLE IV

Comparison of Sardine Catch between Coordinate Months, 1935-36 (*Unit :* 1,000 *metric tons*)

Province	Monthly Catch, 1935					Monthly Catch, 1936					Ratio between Coordin Months			
	Apr.	May	June	July	Aug.	Apr.	May	June	July	Aug.	Apr.	May	June	Ju
North Hamkyong ..	0	7	23	36	32	0	0	13	21	59	—	0.00	0.57	0.5
Kangwon ..	5	22	26	13	2	0	6	13	27	18	0.00	0.27	0.50	2.
North Kyongsang	1	7	13	11	1	1	4	20	18	4	—	0.57	1.54	1.

e table the monthly catch of 1935 is assumed esent a normal one. It is evident from the at the more northerly the locality, the later ason. On the other hand, the southern es enjoyed a longer fishing season than usual greatly increased catch.

evidence points to the undeniable role of teorological phenomena as they initially in- d hydrographical conditions over an expansive sea, which in turn changed the migratory nd season of the fish, and consequently the conditions.

e have been, in addition to these conspicuous esser fluctuations in the fishing circumstances l by local changes of oceanographical condi- These environmental fatcors, therefore, have ed useful information as a basis on which cast the outlook of the sardine fisheries for eason. In more recent years, there was a failure in 1954 and 1955, of the fishing for ize sardine in the north-western waters of u. Although an exact cause remains to be , a tentative interpretation seems to be that high temperatures resulted from abnormally climates in the preceding fall and winter, led the southward migration of the fish m the Japan Sea.

DEPLETION IN THE STOCK

the basis of surveys for sardine eggs and carried out in 1937 Nakai (1938, 1943, 1952) tablished that the Satsu'nan area off the n tip of Kyushu was in those days the most ant spawning ground for sardines of all the regions with the major season from February rch. The amount of eggs spawned was ed to represent about 70 percent of the annual oduced in the seas adjacent to Japan. In the f this evidence, it is believed that in those ie majority of the newly spawned eggs was by the Kuroshio Current to the Pacific coast country, there to hatch out and develop into ung which supported the principal sardine on this side of the Pacific Ocean. The tion appears to be warranted, as the Kuroshio wn to flow, in normal years, through the an area, thence sweeping closely along -misaki, to head approximately east-northeast.

rding to Uda (1940, 1949, 1951, 1952), on er hand, there had been in the high sea off -misaki a symptomatic appearance of a cold nass since 1933, which became predominant and later until it began to decline in 1945. graphic observations conducted by Nakai area during February to March of 1940 and 1941 confirmed the existence of the cold water mass, with the Kuroshio running far away from Shiono-misaki, to make, as it were, a long detour around the area. Another series of surveys carried out since 1947 proved that the expanse of cold water had substantially disappeared from the area, while the Kuroshio was now running nearly along the same course as it did in the previous years.

This phenomenon, one of the most outstanding oceanographical changes ever known in Japanese waters, seems to have had critical effects upon the survival of the sardine postlarvae spawned in the Statsu'nan area in February to March and transported to that area, and to have influenced the ecological conditions in the later period of life, the abundance of the fish and the general fishing situation in almost all the regions adjacent to Japan. The results of the 1940-41 spawning surveys revealed further that the sea off Shikoku, west of the cold water area, was densely populated by the postlarval sardine, despite their being totally absent in the cold water area.

It should be noted in this connection that in the prewar period the Pacific coast extending from Chiba Prefecture northwards to Hokkaido, produced the greater portion of sardine catch of the country, *e.g.*, 70 percent of the annual total as of 1936, the fish mostly consisting of 0- to two-years-olds. However, the sardine output in these regions was sharply impaired after 1942.

The available information has convinced Nakai (1943, 1949) that the primary cause of depletion in the sardine resources of the Far East region in the early part of 1940's was most probably the decreasing survival of the post-larval fish affected by the prevalence of the cold water mass. In spite of the fact that the Kuroshio has resumed its normal flow after 1945 when the cold area ceased to exist off Shiono-misaki, the stock of sardines does not seem to have recovered to its previous abundance. A logical explanation adduced by Nakai (1949, 1951) is that the population was impaired to such an extent that the fish no longer needed to migrate so far as they used to : the spawning migration from the Japan Sea suffers considerably, before it reaches the Satsu'nan area, from purse seine operations northwest of Kyushu ; these two factors together resulted in the gradual movement of the spawning center from the Satsu'nan area to the northwest of Kyushu year after year since 1943.

Leaving the detailed accounts to other occasions, support for this view is provided by the fact that the hydrographical conditions in the Satsu'nan area indicate little difference for the periods under study. Surface temperature in the Satsu'nan area in February to March for the period of 1937 to 1941, when sardines spawned heavily there, ranged 16 to 21°C on the five year average, and the salinity 34.60 to 34.80°/oo. Except for minor fluctuations depending on season and locality, the temperatures and salinities of the area as a whole do not appear to differ sufficiently from the above ranges to justify the sardine spawning elsewhere.

Further evidence is provided by the wide range of optimal temperature for the spawning. In the previous period (1937-41) the sardine eggs were abundantly collected in Satsu'nan and its vicinity when surface temperature read 18 to 20°C. In the northwest of Kyushu and the neighbourhood of the Noto Peninsula on the Japan Sea during 1947 to 1951, the sardines were spawning mainly at 14 to 16°C. For these reasons, there is no doubt that the Satsu'nan area still constitutes a potential spawning ground for sardines, as far as the optimal range of spawning temperature is concerned.

In short prevalence of the cold water area off Shiono-misaki had multiple and far-reaching detrimental effects on the sardine fisheries, causing inevitable reactions of one factor after another, such as the deviation of the Kuroshio from its normal course and changes in ecological conditions relating to distribution, migration and spawning. Even at the present time, when the cold water mass no longer exists in that area, the sardine stock has by no means recovered from the initial depletion inflicted by the abnormal hydrographical condicions more than 15 years ago and its aftermath effects.

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12

SHERIES RESEARCH METHODS OF GATHERING EVIDENCE OF BASIC CHANGES IN MARINE FAUNAL DISTRIBUTIONS

by

A. R. Margetts*

isheries biologist is in a unique position to changes in faunal distributions throughout . The field of his study is geographically ied by the range and type of his country's leets and many of his observations may be any or all of his country's fishermen. He e is frequently able to survey large expanses orld's oceans, especially those where fisheries ecuted.

rom the viewpoint of the fisheries biologist s short paper is written. The scope of investigations is roughly limited to the tion of flora and particularly fauna support- ries, or of the fauna and flora upon which cial fish species are dependent, either directly ectly, as an essential link in their food chain. nnection with fisheries at once introduces antages of wide range and coverage of an l the disadvantages of commercial economic ffecting observations.

changes in faunal distribution, as broadly here, are of two kinds. Firstly, a new may establish itself, apparently permanently, ality where it had hitherto been absent or e, or, vice versa, a species may disappear regular habitat. Secondly, the abundance in species, already long-established in an y undergo changes of such a magnitude as tantially alter the relative abundance of species of animals in the marine community area. Short-term changes, usually rather ich as are occasioned by poor survival of juvenile forms, or by minor catastrophes a sudden temporary change in water con- are not considered here.

y seem rather obvious, but, in the investi- f a basic change in faunal distribution, the should be to establish firmly that a change bution has indeed occurred. Until this has ie there can be little point in trying to eluci- cause of the apparent change. Thus the ue of the individual original observations e accurately assessed, and their limitations ected, especially when the observations are together.

There are commonly available to the fisheries biologist four sources of observation or information which can provide the data for evidence of faunal changes. They are the commercial fisheries, research ships, other ships on regular stations or lines, and publications by or communication with workers in the same field in other states or countries.

COMMERCIAL FISHERIES

The amount and value of information from commercial fisheries is mainly dependent upon two factors, good statistics and good relations between investigators and fishermen. Often the first factor is greatly affected by the second.

The compiling of comprehensive fisheries statistics usually requires the attention of a permanent staff of workers, but good statistics can usually provide a great deal of the data for an investigation of some marine faunal changes.

The most useful form of basic data from the major commercial fisheries is that whereby full information about each voyage of each ship is recorded on one card or sheet of paper. Such records can then be totalled as required. For studying changes in fish distributions an investigator needs to know not only how much of each species of fish a ship has caught and when it was caught, but also the grounds where the ship has fished, how much time was spent in making the catch, and the fishing method employed; fishing methods are generally selective so that no one method, not even trawling, gives a true picture of the fish population on the ground, and the rate of catching fish gives an indication of the abundance of a species.

Examination of a series of records of fishings in any area during the course of years usually shows up changes in fish distribution within that area. Fisheries statistics in Great Britain are detailed enough for the monthly catches of each species to be charted according to where the fish were caught. For convenience the area of the North Sea is divided into rectangles of dimensions 1° longitude by 30′ latitude. Knowing also the fishing effort devoted to making the catches and looking back over the

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* Fisheries Laboratory, Lowestoft, U.K.

records of years it is fairly easy to detect both annual fluctuations and such major fluctuations as may be considered to constitute basic changes in fish distributions.

The fringes of the natural distribution of a commercial fish species are particularly clearly shown when the abundances of fish, measured as amount caught per unit fishing time, are plotted by statistical rectangles. For example, practically all of the North Sea has been regularly fished by English and Scottish steam trawlers for the past fifty years, and from the statistics of landings it is apparent that, in the haddock fishery, apart from the short-term variations, there has been a definite northward recession of the southern limit of haddock distribution. Around 1920 haddock were caught in the southern North Sea, now they are not there. The southern limit of the haddock distribution is now very roughly some 80 miles north of where it was in 1923. The movement of this limit has been a gradual one.

From a similar type of statistics for the Atlantic hake fishery the conclusion may be drawn that there has, over the past twenty years, been a shift northwards of at least part of the hake population. More hake are now caught further to the north and northeast than used to be the case, and the rate of catching hake on the grounds to the west of Scotland is now relatively greater than that on the grounds to the south of Ireland (some 150 miles to the south) than it was before 1939.

But statistics cannot always be accepted at their face value, especially because they are affected by the economics of fishing. In the quoted examples above, the conclusions about North Sea haddock are likely to be correct, while those about hake are more open to doubt. The relative value of haddock remained steady during the period of observation and the whole of the area, including the fringe of its natural distribution, was regularly fished. The market value of hake in relation to other sorts of fish increased very markedly after 1939 so that there was more incentive for the fishermen to search especially for hake and to pay more attention to the grounds near the fringe of its distribution where previously the gear used was adapted specially for catching other species; on such grounds an apparent change in hake abundance may not have been a real change but due only to more efficient catching.

The decline or even end of a fishery cannot be assumed to be due to scarcity of fish unless economic factors and change in fishing activity have been shown to have played no part. For example, the drift-net fishery for herring in the English Channel off Plymouth in the inter-war years was unremunerative for several years in succession and so declined to the point of extinction. The ships which had previously joined in that fishery found emp elsewhere and have never returned. But i not be safe to conclude that herring are no l be found on those grounds. In recent years herring trawlers have taken good catche roughly the same region where the drift-net used to exist. Maybe, if drifters had pers they would again have eventually made good But they could not afford to persevere.

Similarly, records of catches from new a bigger catches from near or distant groun probably be due more to improvement in ships and fishing technique rather than to any in the distribution of abundance of the fish. ever, one example of a new fishery dev because of a new presence of fish is the cas Baltic cod. During World War I, German trawlers tried fishing in the Baltic because the North Sea grounds were closed. They caug flatfish and no quantity of cod. But in Wo II the same switch-over of fishing was mad and then large quantities of cod were caugh Baltic; these catches have been maintained s war. In Arctic fisheries in the Barents S southern ice limit restricts the fishable area d tly each year.

Statistics show a very marked decline dur last fifty years in the English shellfishe molluscs, with many local fisheries having closed. In this case, further scientific in tion has revealed that the decline was due to bination of over-fishing and heavy parasitis some of the shellfish rather than to any change in distribution.

Fishermen are usually keen and accurate ob not given to freely reporting their observati good personal relations exist between the fis and the investigators, then the fishermen ca advantage to the investigator, be encoura report unusual changes on the fishing grou the catching of rare fish, or the appearance of other animals on a fishing ground where he found them before, and so on. This repo best done informally.

No great importance is to be attached to dividual reports themselves, but when th collected together they may clearly indicate in animal distribution. They will normall attention to the beginning of a faunal chang area. After first reports of unusual occu the subsequent likely lack of reports can mea that the something new is now establish regular or that it was only a temporary occu with the existence of good relations between tigator and fishermen, further enquiry i question is easy.

ample of the use of such simple and inex-
observations is the recording of the occur-
rare fish species from Scottish fisheries ;
l influxes to the North Sea of Atlantic water
the North Sea fish species not normally
ere.

RESEARCH SHIPS

ch ships are expensive to operate, but from
stigational point of view have the great
es of being adaptable and making accurate
ons of both fish and other organisms in-
tly of any commercial or economic con-
ns. In fisheries research, observations on
stributions can often be made from research
ncidentally to the main aim of a cruise.
he course of regular trawlings for cod in the
Sea by the research ship *Ernest Holt* speci-
invertebrate benthos have been collected
distribution plotted ; when recent collec-
re compared with all available records of
es of some species during the previous
ive years, it was found that a number of
previously found only in the southern and
stern parts of the Barents Sea, are now
y found much further to the north and
t, even around Spitsbergen, and that
ously the southern limits of the strictly
ecies had moved northwards. It has been
d that these two types of animals, termed
nience ' warm water ' and ' Arctic ' can be
ndicators of distribution of water masses of
g temperatures, the fisheries production of
y be widely different.

rom being able to make observations where
required, the research ship also provides the best means of studying animal distributions quantitatively. The gear are specialised, more efficient for some particular purposes than commercial fishing gear.

FIXED STATIONS

Regular series of observations from regular positions will, in time, show marine faunal changes. The regular positions can be lightships or weather ships on station or ships on a regular line. If these ships are provided with suitable simple and robust sampling devices a watch can be kept on the constitution of the plankton. The results must be interpreted carefully, and special regard paid to the position of fixed stations in relation to the water movements and possible changes in major current systems ; otherwise direct comparison between observations may not be valid.

INTERCHANGE OF INFORMATION

Basic changes in marine faunal distributions usually affect such vast areas that evidence of their occurrence is usually collected, *albeit* in small amounts and sometimes unwittingly, in several countries simultaneously. That this evidence should be publicised, and as soon after observation as possible, is highly desirable. A free exchange of information between investigators in the same field cannot fail to expedite discovery of faunal changes and perhaps also avoid wastage of effort by avoiding duplication of work. Such an organisation as the Conseil International pour l'Exploration de la Mer is of great value in bringing together independent observations on the fauna of immense sea areas and in the co-ordination of independent programmes of research.

13

CORRELATION OF HYDROGRAPHIC AND METEOROLOGICAL FEATURES WITH THE FLUCTUATIONS IN CERTAIN FISHERIE IN THE WATERS OFF JAPAN

by
M. Uda*

The anomalous feature of the Kurosiwo Current during the years from 1936 to 1947 is a remarkable example of hydrographic variation. The winter fishery of the yellow-tail along the Pacific side of Japan was of good intensity in the years 1924, 1938 and 1952—years in which unusually strong current conditions prevailed in association with the anomalous behaviour of the Kuroshiwo, resulting in heavy damage to many set nets.

The years 1936 to 1940 were comparatively warmer both in the Japan Sea and the Pacific Ocean and these were years of rich sardine, skipjack and tunny fisheries which declined in the colder years which followed (1941-1947). This colder period was however associated with an increase in the squid and the Pacific saury fisheries. But with the gradual rise of the water temperature from the coldest years of 1944 and 1945 back to the normal by about 1948 and 1949, the yields of the small tunas and the large sardines slowly increased along the coast on the Japan Sea side.

The sardine fishery was abundant in the northern part of the Japan Sea from 1923 to 1940 but declined rapidly from 1941 along the coasts of Northern Korea and Hokkaido. It is presumed that during the warm years the fishery stretched to the extreme north; for the return of the adult sardines to the spawning ground to the southeast of Kyushu in autumn and winter was checked by the warm northward current. The journey to the spawning ground in the peak period of spawning was thus obstructed, and even the eggs and larvae spawned on the way were destroyed by the sudden cold in the autumn and winter. In this way the sardine stocks were considerably reduced.

Based on the survey made by the Soyo Maru it has been shown that, as compared with the spring of 1932, in the spring of 1941 the spawning populations of the Pacific saury abounded with eggs and larvae in waters of 16°-18°C in the Japan Sea while long-line samples from depths of 50-200 m. showed pollack to be plentiful especially in the zone of upwelling of the cold water mass at temperatures from 1° to 3°C.

The fluctuations in the abundance of the
of *Euphausia pacifica* Hansen in the Ja
affords another instance of the correlation
perature with such phenomena.

From January to May 1948 the swarm
abundant on the coast on the Japan Sea sid
dense swarms moved successively along t
from Gotō Island in the Nagasaki Prefe
Wakasa Bay, coinciding with the migra
sardine, mackerel and squid. The tem
pattern showed that these movements corre
to a shift in the optimum temperature
12°-14°C.

As with the cold water circulation in th
Sea, in the Okhotsk Sea the range of the dic
water (3° to -2°C) representing the Oyasiwo
which results from melting ice, extended
south, year after year, from 1939 to 1942.
increase in the yields of squid and Pacif
appeared in recent years after 1945.

During the past 200 years poor rice cr
occurred in several years† $(\surd\infty\sqrt{P_s-P_a})$ on th
east coast of Japan when the anomalous b
of the prevalent cold Oyasiwo Current res
unusually cool summers. These cool yea
somewhat similar climatic features to nor
ters, i.e. the development of the Siberian H
and the Aleutian Low (P_a) due to the preva
the northward warm current (a branch o
Drift Current) in the preceding year. Conse
the greater the pressure gradient, the stro
winter monsoon $(\surd\infty\sqrt{P_s - P_a})$ strengthe
anticyclonic atmospheric circulation around t
tian Low.

Finally, the Oyasiwo Cold Current pushe
wards from the Okhotsk Sea along the Kuril
on the Pacific side. Hence, a year of prepon
of the northgoing warm current (rich crop
and rich tuna fisheries) precedes a year of
derance of the southgoing Oyasiwo Cold
(poor rice harvest, cool summer, good fis
squid, pacific saury and winter yellow-tail

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* The Tokyo University of Fisheries, Japan.

† 1755, 1783, 1833, 1837, 1866, 1869, 1884, 1902, 1905, 1913, 1923, 1931, 1934, 1941, 1945 and 1953.

e, after such southward incursions of the
rrent, the increased water density in com-
with the pressure gradient due primarily
North Pacific High and secondarily to the
High again induces the cyclic northward
the warm current.

there is a succession of rich years and poor
oth as regards the fisheries and the rice har-
It has been seen that the years of cool sum-
Northern Japan are preceded by a winter in
here is a characteristic distribution of water
ture as between an area of temperatures
than normal in the Northwestern Pacific
Kamtchatka and an area of temperatures
than normal in the Northeastern Pacific
northeastwards to the Aleutians. This might be called the law of regional correlation of water temperatures.

These phenomena may be compared with those found in the North Atlantic Ocean, substituting the Gulf Stream for Kurosiwo, the Labrador Current for Oyasiwo, the Icelandic Low for Aleutian Low etc.

The northward movement of fishing grounds and the decline of the herring fishery off Hokkaido, the cod fishery in the Japan Sea and the whaling industry in the North Pacific Ocean adjacent to Japan, may well be correlated with the secular variation of oceanic climate and particularly with the warming of the Arctic Ocean, as has been pointed out in the case of the North European fisheries.

14

HE ROLE OF THE WORLD METEOROLOGICAL ORGANIZATION IN PROVIDING WEATHER INFORMATION FOR FISHERMEN

by

the World Meteorological Organization

er never ceases to interest a fisherman or to
his life. The design of his craft and gear,
ss of his operations and even his safety are
it on his knowledge of the weather and
of the region in which he operates. It is
extremely important that fishermen be
the current possibilities of obtaining weather
ion, that they ensure that use is made of all
information and, finally, that they study the
ies of improving on the scope and quality
formation at present available.

Vorld Meteorological Organization is the
ed Agency of the United Nations respon-
arranging that National Meteorological
provide, jointly or severally, a global system
rological information designed to meet the
shipping and fishermen on the high seas
oastal waters. Ideally the following infor-
hould be made available to fishing operators :

Day-to-day prognoses and warnings of
gales, storms, ice and other elements
which have a bearing on the operation
and safety of fishing fleets ;

Medium and long-range specialized forecasts which allow planning, ahead of time of operations and itineraries, and

(*c*) Information in the form of statistical means and variations from them, as well as extreme values of significant meteorological elements for the region of operations.

The provision of day-to-day forecasts and warnings for the benefit of sea-going vessels has engaged the attention of WMO and its predecessor, the International Meteorological Organization, for many years. A worldwide plan has been established for broadcasting weather information for the benefit of all vessels which are equipped to receive it. The responsibility for these broadcasts is shared by the various maritime countries in accordance with a plan which allocates areas to each of them.

For the benefit of fishing vessels which are not fitted with radio, provision is made on an international basis for visual storm warning signals to be exhibited at harbours and at prominent points of land. The normal procedure is for the Meteorological Service of the country concerned to issue the warning and for some other appropriate authority to exhibit the visual signal on receipt of the warning.

Weather bulletins issued by radio for shipping on the high seas consist of the following parts, in the order listed :

Part	I	*Storm warnings*
Part	II	*Synopsis of meteorological conditions in the forecast area*
Part	III	*Forecasts*
Part	IV	*Analysis and/or Prognosis* (optional)
Part	V	*A selection of ship reports* (optional)
Part	VI	*A selection of land reports* (optional)
Part	VII	*Additional ship reports* (optional)
Part	VIII	*Additional land reports* (optional)
Part	IX	*Upper air reports* (optional)
Part	X	*Aircraft reports* (optional)

Weather bulletins are also issued by radio for shipping in coastal waters but the contents of these, apart from the provision of gale warnings which is obligatory, is a domestic matter. As a general principle these coastal bulletins include, in addition to gale warnings, a general statement of the existing weather and forecasts of the weather twelve hours or twenty-four hours ahead.

Of course, the accuracy of weather bulletins depends, to a great extent, on the accuracy and number of meteorological observations on which they are based. Hence, there is a mutual dependence between ships and meteorological offices of maritime countries, the latter issuing weather bulletins and warnings and the former supplying the observations on which these bulletins are based. In view of this inter-dependence, the World Meteorological Organization has enlisted the help of more than two thousand ships which, several times daily, transmit, free of charge, meteorological observations to certain designated coastal stations which, in turn, transmit them to collecting centres responsible for disseminating them in collective weather messages on which weather forecasts and warnings for ocean areas are based. In order to assist in instructing voluntary observers on board ships, Meteorological Services of maritime states usually appoint liaison officers with marine experience at their major ports. On request, these officers make themselves available to ships of all countries for the purpose of servicing meteorological instruments, providing information regarding storm warnings, forecast messages, etc., and in general helping to solve any difficulties which may arise.

In ocean areas where the maritime traffic is heavy, an adequate network of meteorological observations is thus made available. In other ocean areas, owing to the paucity of merchant shipping, the number of observations available is much less than is de
In such areas the co-operation of fishing fl
reporting meteorological observations become
desirable. The improved forecasts and w
which result should be an incentive for own
fishing vessels to co-operate. Thus a sche
been devised by this Organization whereby v
factories in the Antarctic are enabled to
meteorological observations to designated stat
Australia and South Africa without disclos
position of their ships. The scheme is now
third year of operation and has proved suc
Thousands of observations have been conti
by whalers participating in the scheme, s
whom have reported on its usefulness resultin
fuller collective messages and better prognos
warnings issued for their benefit. Another i
is that of German trawlers which report more
hundred observations daily while fishing in
waters and while on their way to and from
fishing areas. A certain number of British t
also send reports when in this area.

These radio weather messages from sh
transmitted in a simple numerical code.
case of fishing vessels the message could be ex
brief and only contain observations which a
mally made by a seaman in the ordinary co
his duties.

The provision of medium and long-rang
casts, listed under (b) above, is, with a few
tions, a matter for the future. But already
beginning in this direction has been made b
countries. However, it will be some time
fishing units are able to obtain detailed and spe
medium and long-range forecasts in all parts
world.

There is available in the archives of the
rological Services of maritime countries a co
able collection of maritime climatological
Much of this data has already been used to c
climatological atlases of the oceans, a relevant
which is included in Annexure I. A recent
undertaken by the World Meteorological O
zation shows, however, that there are vast reg
the oceans where the number of available
vations is not sufficient ; this is especially t
regions far from the international shipping
If more observations were available, the accu
the atlases prepared by the various nations wo
much improved, and this question is being a
considered by the World Meteorological O
zation. Here again, observations contribut
fishing vessels in remote areas will be of inest
value and will, in the long run, be very benef
fishing operations, for the design of fishing cra
gear and in the handling and processing of fis

onclusion, it is clear that the Indo-Pacific ;s Council can help fishing units by adver- he facilities provided by Meteorological Ser- ıd urging them to equip their fleets to receive It is also clear that it is to the immediate and nge advantage of the fishing industry that ssels co-operate in supplying meteorological tions to supplement those supplied by mer- hips, especially where maritime traffic is not The World Meteorological Organization able to satisfy this Council that the obser- which are needed are simple to make, do not much time, and that no cost to the fishing r her owners is involved.

xure I.—List of climatological atlases or having climatological maps of oceanic regions, ecial reference to Asia and the Far East.

ıeral

of Climatic Charts of the Oceans U.S.W.B., ashington, 1938.

ian Ocean

thly Meteorological Charts of the Indian Ocean (*M.O.* 519)—Meteorological Office, ndon, 1952.

Climatological Atlas of the Indian Ocean (all months, on loose monthly charts)—Royal Netherlands Met. Institute.

Red Sea and Gulf of Aden (all months, in one part)—Royal Netherlands Meterological Institute.

Meteorological Charts of the Red Sea—London, 1895.

3. *Pacific Ocean*

Monthly Meteorological Charts of the Western Pacific (M.O. 484)—Meteorological Office, London, 1945.

Monthly Meteorological Charts of the Eastern Pacific (*M.O.* 518)—Meteorological Office, London, 1950.

China Seas and the Western Part of the North Pacific Ocean (all months in two parts)—Royal Netherlands Met. Institute.

Sea Areas around Australia (all months, in one part)—Royal Netherlands Met. Institute.

Meteorological Charts of the North Pacific Ocean—U.S. Hydrographic Office, 1878.

Atlas of the Pacific Ocean—Hamburg, 1896.

Currents and Meteorological Charts of Seas near Japan—Tokyo 1926.

15

TRAWLING RESULTS OF *TAIYO MARU No.* 11

by

U Ba Kyaw*

Maru No. 11, a Japanese travler, d in the territorial waters of Burma during riod from 19-11-53 to 12-6-55. It has a nnage of 278 and is powered with 500 B.H.P. engine for propulsion. It was manned by of 21. The headrope of the trawl net used meters in length and the cod-end mesh was n stretched.

rds of the above trawler for 20 successive trips in 5 different areas were analysed and ılts are appended.

catches were mainly marketed in Rangoon suburbs where the consumers still show a preference for freshwater fishes. Smaller fishes (even up to about 5″ in length) in the catch had to be discarded as they were not economical for marketing. They constitute about a fourth of the catches in the areas C, D and E and a third of the catches in the areas A and B. An intensive campaign undertaken by the operators in consultation with the Government Fisheries Division for sales promotion is having a good effect on the consumers. The retail price per viss† in Rangoon of fresh water fishes is 3 to 8 Kyat‡ while that of sea fishes 2 to 5 Kyat, although the latter is expected to increase as the market improves. It is premature to estimate the maximum fishing effort which the natural resource can support when there is still plenty of room for expansion of the trawl fishery.

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xecutive Officer (Fisheries), Agricultural and Rural Development Corporation, Union Government of Burma.
Viss = 1.65 kilograms.
4.76 = 1 U.S. dollar.

TABLE I

Summary of the Trawl Operations by Taiyo Maru No. 11

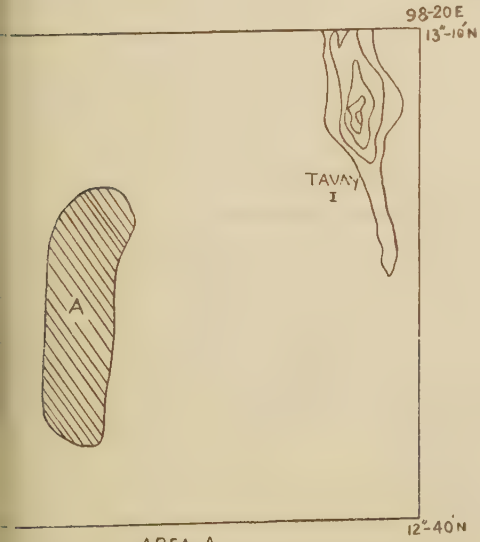
Area	Average Depth (Meters)	Nature of Bottom	No of trips	No. of drags	Fishing time (hours)	CATCH*		Species in order of abundance.
						Amount (Kg.)	Average per hour (Kg.)	
A	54	green mud	11	476	2,325	462,930	199	Sciaena sp., Lutjanus sp., Leiognathus, sp., Pomadasys sp., Saurida sp., Carcharhinus sp., Ilisha sp., etc.
B	34	green mud	3	102	473	121,563	257	Pomadasys sp., Leiognathus sp., Lutjanus sp., Sciaena sp., Saurida sp., Carcharhinus sp., Ilisha sp., etc.
C	32	Soft gray mud	4⅔	202	907	168,012	185	Pomadasys sp., Sciaena sp., Ilisha sp., Carcharhinus sp., Leiognathus sp., Saurida sp., Arius sp., etc.
D	28	Soft gray mud and sand	1	42	199	32,390	159	Pomadasys sp., Sciaena sp., Ilisha sp., Muraenesox sp., Carcharhinus sp., Arius sp., Chirocentrus sp., etc.
E	38	gray mud	⅓	19	68	14,255	210	Sciaena sp., Pomadasys sp., Arius sp., Ilisha sp., Saurida sp., Upeneus sp., Carcharhinus sp., etc.
Total			20	841	3,972	799,150		

*Landed catch.

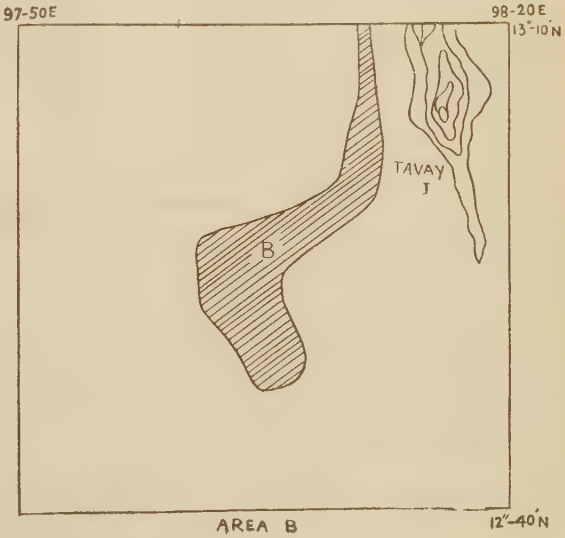
TABLE II

Composition of Landed Catch by Area (Kilograms)

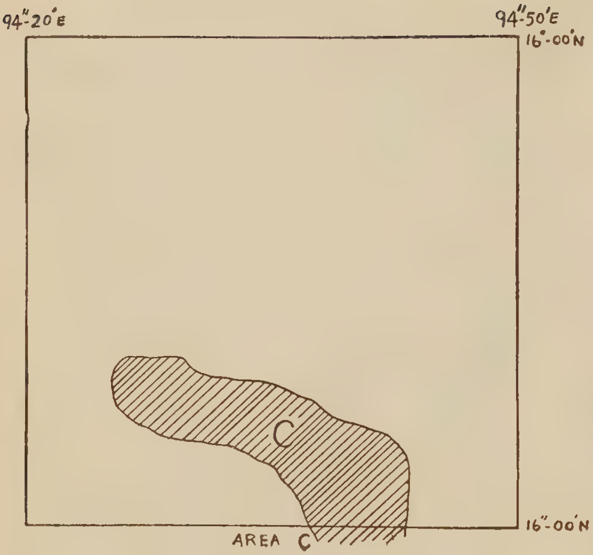
SPECIES	AREA					REMARKS
	A	B	C	D	E	
	1,423.5	78	448.5	—	—	
.	858	429	1,599	1,033.5	175.5	
us sp.	28,314	5,148	13,591.5	2,437.5	682.5	
.	—	2,067	—	—	—	
.	19.5	—	468	—	—	
s sp.	4,894.5	975	6,357	1,092	351	
	26,325	4,758	17,764.5	3,100.5	1,345.5	
sp.	15,853.5	2,242.5	8,209.5	2,457	312	
	16,633.5	3,841.5	8,580	2,086.5	1,638	
.	31,453.5	7,293	11,583	604.5	858	
ta	7,995	1,794	4,173	546	273	
sp.	7,293	1,170	312	39	—	
sp.	78	—	—	58.5	—	
	2,613	663	5,538	624	351	
sp.	11,719.5	1,248	1,774.5	117	58.5	
sp.	468	195	1,443	—	195	
	10,491	3,178.5	4,972.5	390	214.5	
s sp.	55,282.5	18,447	12,714	—	370.5	
rifer	1,930.5	—	175.5	—	—	
.	57,057	16,263	2,574	390	136.5	
sp.	53,898	25,486.5	26,013	5,947.5	1,677	
	92,566.5	16,126.5	19,461	4,426.5	2,379	
.	546	351	4,134	1,014	429	
.	6,318	507	8,307	760.5	858	
sp.	11,719.5	1,872	3,061.5	19.5	175.5	
	17,179.5	7,429.5	4,758	5,246	1,775	
l	462,930	121,563	168,012	32,390	14,255	



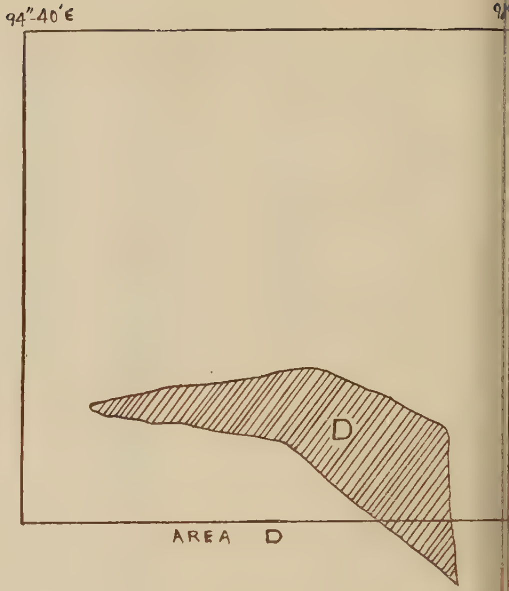
AREA A



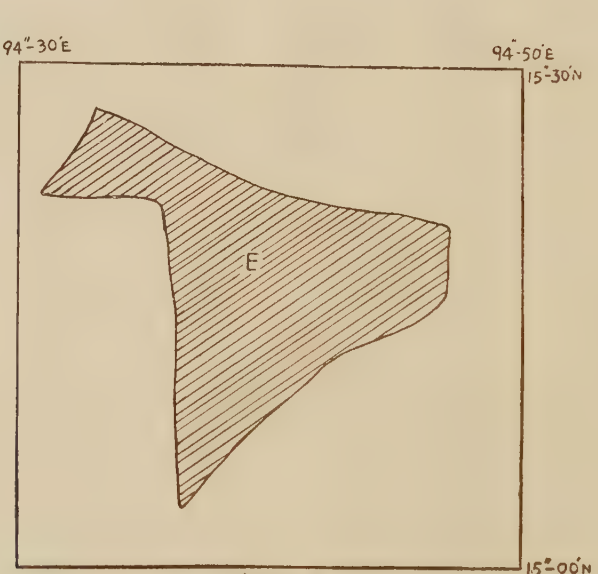
AREA B


94°-20'E
94°-50'E
16°-00'N
C
16°-00'N

AREA C



AREA D


94°-30'E
94°-50'E
15°-30'N
E
15°-00'N

AREA E

16

CURRENT STATUS OF FISH FINDERS IN JAPAN

by

S. Kawada*

se of fish finders in Japan has increased : year in the main fisheries except those for and tuna. The wave-frequency of fish enerally ranges from 10 to 100 kilocycles, there are fish finders of frequencies of 200 ilocycles for special purposes.

se of ultrasonic echoes has resulted in many nents in fishing gear and methods, and in vledge of fishing grounds, of behaviour of and of submerged gear, the interrelation- een all three, as will be seen from the follow- iples.

t fisheries.

er to know the capacity of a set net and to ata for its improvement, the movement ol of fish (horse mackerel) in the vicinity ifferent parts of the net (leader, entrance, d, and ramp) were observed (Table I and . The number of fish entering and leaving the net and their swimming speed were recorded and a diagram of the fishing ground was drawn together with the courses of fish from the off-shore waters into the set net and the state of the set net in the water.

(ii) Drift gill net fisheries for sardines in the Japan Sea.

The daily vertical migration of a school of sardines has been surmised. Catches by drift gill nets during the night have been improved in certain fishing grounds so that schools of sardine can be caught in any fishing ground at any time.

(iii) Alaska pollock (*Theragra chalcogramma*) fisheries in Hokkaido.

Fishing gear have been greatly improved, to the extent of raising catching efficiency by ten times through the observation of seasonal changes in the swimming habits of this species.

TABLE I

Behaviour of Schools at the Main Parts of Set Net

tem	Leader	Entrance	Interior part of entrance	Ramp
hool	Large	Medium	Small (a school is broken up)	Small
speed of ol	—	0.05-0.55 m./sec. (mostly) 0.15-0.35 m./sec.	—	—
r swimming	2-30 m. (mostly 8 m.) at the sea depth of 42 m.	2-30 m. (mostly 8 m.) at the sea depth of 55 m.	about 10 m. (mostly 6 m.) at the sea depth of 58 m.	About 10 m. (mostly 5-6 m.) parallel to sea level
etween net hool	5-20 m. Schools do not usually pass through the leader	In the case of 49 m. wide, most of fish pass through the center of the entrance	5-20 m. Schools do not usually pass through the interior part.	In parallel to the sea level, about 90% of school comes up along the seaward side, of the ramp, all keeping away from the bottom.

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ef, Fishing Method Division, Tokai Regional Fisheries Research Laboratory, Tokyo, Japan.

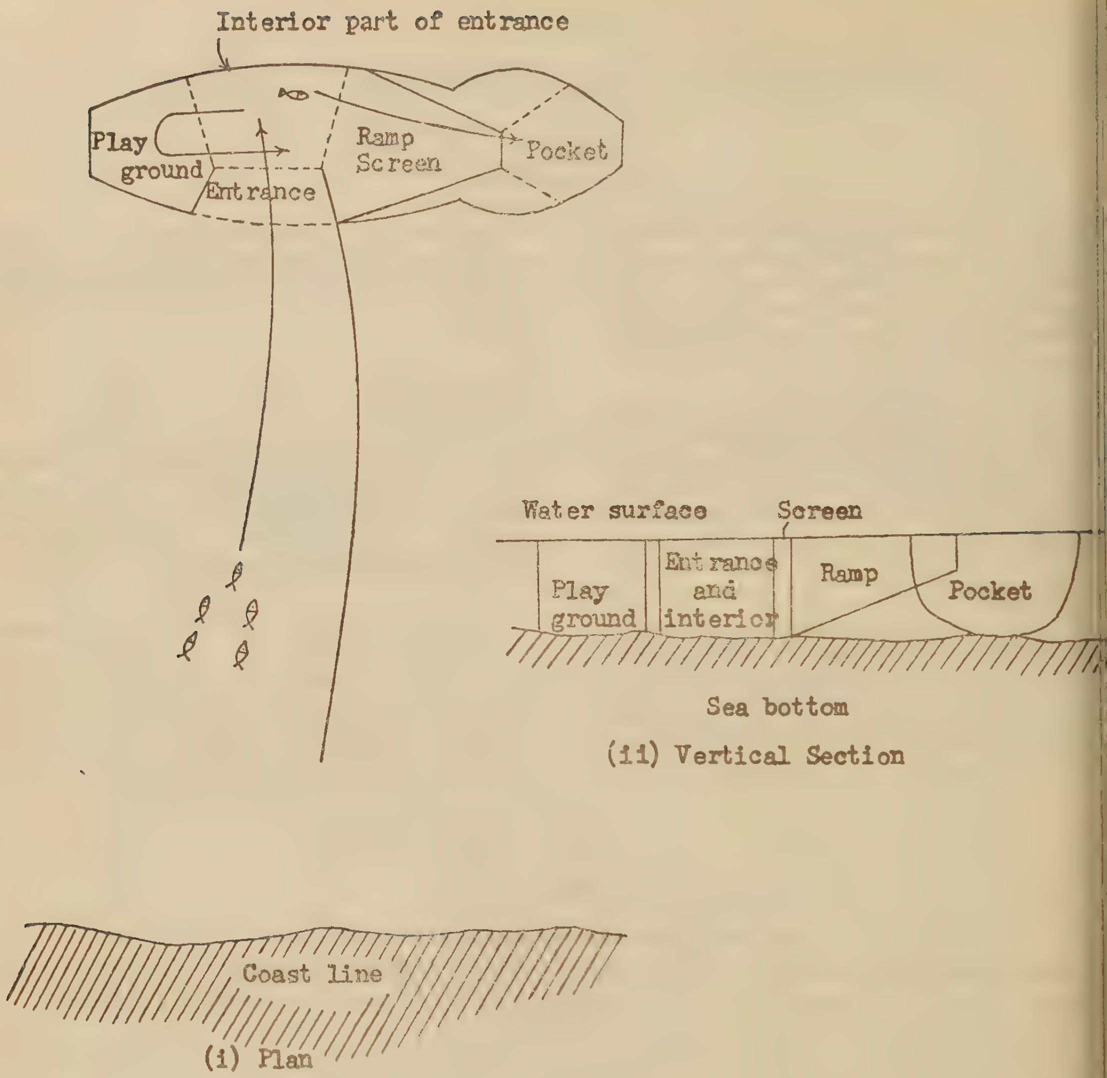
Interior part of entrance
Play ground
Entrance
Ramp
Screen
Pocket
Coast line
(i) Plan
Water surface
Screen
Play ground
Entrance and interior
Ramp
Pocket
Sea bottom
(ii) Vertical Section

Fig. 1. Diagram of Set Net.

(iv) *Hachida-ami* (sardine net) fisheries.

Fishing grounds have been extended, catch rate raised and time for net casting reduced, with a corresponding increase in fish production, by observing the daily movements of schools of sardines.

(v) Herring fisheries.

Herrings which were caught in set nets and gill nets in certain places were found to congregate on the sea bottom in the daytime, rising only at night. Herrings are now caught in drag nets at any time on any fishing ground. Such technical improvements are contributing to freshness, fish price stabilization, and to saving of material and labor.

(vi) ' *Shiomachi-ami* ' (tidal net) fisheries.

Study of the correlation between the defor of nets by tidal currents and their fishing ca has resulted in improvements in net constr and setting, with a correspondingly inc production.

(vii) Squid fisheries.

Accurate detection of the frequent chan movement of schools of squid is most imp and great improvements have been made techniques of selecting angling places for sq

(viii) Round haul fisheries.

The success of these fisheries depends on the determination of the movement of sch

sh finders are playing an increasingly
t role in adding to our knowledge of these
nts, with a corresponding saving of time and
ı of risk.

p-sea shark longlines and drag net fisheries.
levelopment of deep-sea fishing grounds is
ged for Japan to mitigate the limitations of
tal fisheries. Fish finders have, therefore,
indispensable and will undoubtedly
te much to the development of deep-sea
in the future.

eys of fishing grounds.
g grounds are to the fishermen what farm-
to farmers and precise charts of fishing
are indispensable to the fisheries administra-
hart making methods by the use of fish
as been summed up in a handbook for the
shermen throughout the country.

(xi) Submarine fish shelters.

Studies have been made with fish finders of the shapes of submarine fish shelters and the means of inducing fish to use them.

(xii) Development of coral fisheries.

Great improvements in coral production has recently been brought about by means of fish finders; coral is usually found in depths and places inaccessible to other searching methods.

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17

YNTHETIC FIBRE FOR FISHING NETS AND ROPES IN JAPAN

by

H. Miyamoto*

ynthetic fibre industry has undergone rapid
hent in Japan since the end of the Second
Var and fundamental experiments relating
se of these fibres for fishing nets have been
ut since 1948. They were first adopted to
ishing operations by some fishing concerns
and by 1953 they were in general use in
et, seine net, trawl net, gill net, lift net and
fisheries.

nnual consumption of all kinds of fishing
erials in Japan is about 23,120 thousand
In 1953, about 2,530 thousand pounds
etic fibres, or 11% of the total material
l, were used in fishing nets and ropes instead
ibres; and the production of synthetic fibres
increased to 3,740 thousand pounds in
'hus, many fishing industrialists have
over to synthetic fibres instead of cotton
la hemp, which deteriorate rapidly, with
efit to the industry.

It is therefore thought that in a few years, there may cease to be a demand for cotton or Manila hemp in the Japanese commercial fisheries. This appears to be borne out by the data given in Table I showing the monthly production of synthetic nets and ropes in these two years. There are three principal kinds of synthetic fibre products in Japan, namely: the polyamide compounds, of which one brand in Japan is 'Amilan' corresponding to 'Nylon' in the United States; secondly, the polyvinyl compounds, such as 'Cremona' and 'Mewlon,' etc.; and lastly, vinylidene chloride, marketed under the names 'Saran' and 'Kurehalon'.

PROPERTIES OF VARIOUS SYNTHETIC FIBRES

Breaking strength.—When spun into threads equivalent to No. 20 cotton yarn of two or three plies, most synthetic fibre products have a tensile strength equal to or greater than natural fibres having the same number of plies, in wet condition, as is represented in Fig. 1.

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*Chief, Fishing Gear Division, Tokai Regional Fisheries Research Laboratory, Tokyo, Japan

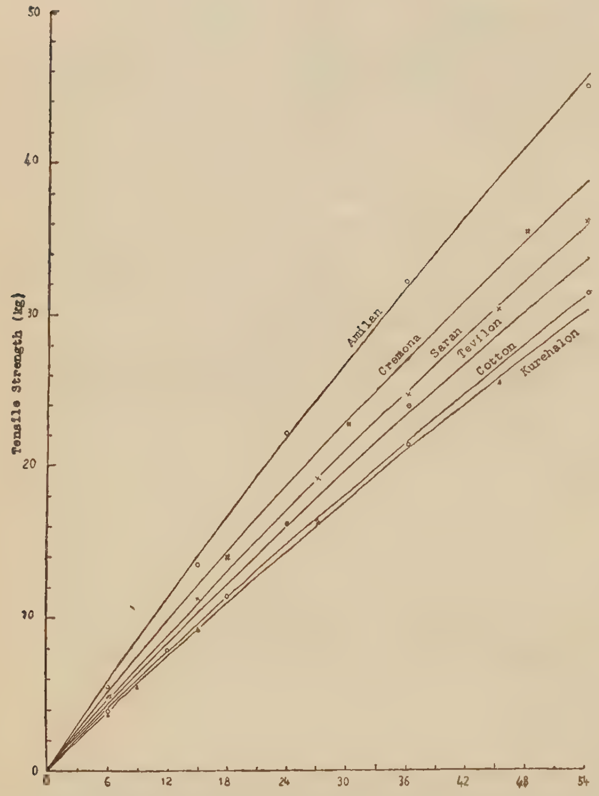

Figure 1. Dry Stretch at Breaking Points.

Numbers of yarn converted equivalent to No. 20 count cotton yarn.

Strength at knot.—Generally speaking, the decrease in tensile strength at the knot is slightly greater in synthetic than in natural fibres, and the loss of strength is in direct proportion to the degree of twist. It is possible to compensate this defect by using the synthetic fibre thread lightly twisted, or by using the knotless net (spliced knot net). The tensile strength of synthetic fibres is, however, increasing so rapidly that the decrease in the tensile strength at the knot may soon be of little importance.

Stretch.—The degree of the stretch of various types of thread under a weight increasing up to their breaking points is given in Figure 2. It will be seen that the stretching qualities differ considerably with the kinds of thread, but that the difference compared with natural fibres is not great.

Also, the elongation of the synthetic fi
adjustable technically to some extent.

Hardness of thread.—The hardness
thread has a great influence on the catching eff
of certain fishing gear. Although the hard
the thread of synthetic fibres can be varied by
sing at different temperatures, polyamide com
are particularly suitable for gill nets beca
their extreme pliancy. Polyvinyl compound
are more pliant than cotton thread, while s
the vinylidene chloride compounds are hard
more pliant than Manila hemp.

Specific gravity of fibre.—The specific
of both polyamide and polyvinyl compou
very low (around 1.14), while those of viny
chloride are quite high (up to 1.7). Differe
specific gravity influence the catching effi
of certain types of fishing gear. In the case
set net, which is one of the most important

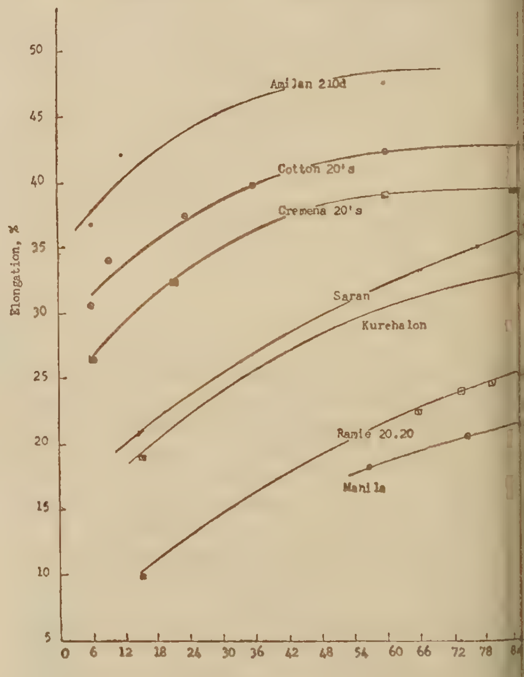

Figure 2. Wet Elongation at Breaking Point

Numbers of yarn converted equivalent to No.
cotton yarn.

industries in Japan, a net made of the forme
easily change its shape in the water under the
of the current, and these compounds are th
not suitable for this purpose. This is not h
the case with vinylidene chloride which is
suitable for set nets because nets made of th
keep their shape better in the current.

on.—Synthetic fibres of the polyamide e very resistant to abrasion, and their may be ten or twenty times that of natural The durability of polyvinyl compounds is different from that of cotton thread, but e chloride is much more resistant to than natural fibre.

ance to light and chemicals.—Synthetic the polyamide group have the disadvantage become fragile if exposed to ultra-violet e tensile strength of polyvinyl compounds ed by acids whereas vinylidene chloride be more resistant.

ance to rotting.—All synthetic fibres outstanding characteristic that they are acked by septic bacteria whereas cotton ila hemp will not last even half a year in shing industries ; it was recorded that the rength of synthetic fibre which had been t use for four years did not change. This btedly the principal advantage of the synthetic fibres and the reason why they are rapidly taking the place of natural fibres.

UTILIZATION OF VARIOUS SYNTHETIC FIBRE NETS

Polyamide compound fibres.—This compound has been principally adopted to the gill net industry. In particular, the salmon drift nets operated in the northern part of the Pacific Ocean, are almost exclusively made of this type of fibre instead of the usual ramie webbing, with great benefit to these industries. This kind of products is also utilized for purse seines, trawl nets, small set nets, etc.

Polyvinyl compound fibres.—This product is replacing cotton nets for purse seines set nets, gill nets, tuna longline, etc.

Vinylidene chloride fibres.—This product is utilized for various set nets and trawl nets, and is replacing Manila twine nets in those fisheries where the latter was previously used.

TABLE I

Production of Synthetic Fibre Net & Rope in Recent Two Years (Unit, 1,000 lb.)

Kinds	*Fishing Net in 1953*												Total
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Nylon	67	73	135	133	116	52	109	109	109	113	118	152	1,286
Vinylon	24	48	42	66	51	53	66	74	77	64	107	58	730
Vinylidene Chloride ..	10	7	11	20	19	39	44	65	90	72	91	67	535
Total	101	128	188	219	186	144	219	248	276	249	316	277	2,551
	Fishing Net in 1954												
Nylon	167	193	236	222	188	176	132	109	99	147	175	174	2,018
Vinylon	71	110	111	120	79	72	55	87	107	117	86	75	1,090
Vinylidene Chloride ..	48	44	37	51	34	45	77	80	66	43	37	17	579
Ramelon	—	—	—	—	—	9	—	—	3	4	18	4	38
Total	286	347	384	393	301	302	264	276	275	311	316	270	3,725
	Fishing Rope in 1953												
Nylon	—	—	1	1	—	2	1	7	8	7	7	4	37
Vinylon	—	—	—	—	—	—	2	4	4	3	4	11	28
Vinylidene Chloride ..	—	—	1	1	—	1	5	5	13	5	2	2	35
Total	—	—	2	2	—	3	8	16	25	15	13	14	99
	Fishing Rope in 1953												
Nylon	6	8	12	5	6	9	6	9	7	10	12	4	94
Vinylon	2	2	3	3	2	2	3	4	9	4	8	4	46
Vinylidene Chloride ..	19	4	4	14	4	2	10	17	27	32	25	10	168

18

RICE STRAW NET & ROPE AS INDIGENOUS MATERIALS

by

S. Takayama*

rocess of evolution of fishing gear, there cases where gear made from indigenous are in popular use, based on the pressures ional economy, even though they may not logically the most satisfactory.

an agricultural country and rice produc- been of the utmost importance since nes. The utilization of rice straw in the mats and ropes has become a common industry. It is therefore natural that ucts should have had a wide application ing industry.

dvances in fishing gear technology, the f the durability of materials and in parti- preservation of straw nets and ropes has prominence and has been keenly studied back as 1910. Preservatives, having been y applied to set nets for the above materials, are more extensively used than s of nets.

ly hemp and ramie had been the principal ised for the manufacture of fishing gear, the development of preservative dyes, oved to be a more effective medium. synthetic fibre nets appeared to present ibilities and as a matter of fact, fishing ow being manufactured on a large scale plastic yarns by recommendation of the government, although there is still much scope for improvements in respect of their application to particular types of fisheries.

In spite of the advent of these revolutionary innovations, the rice straw fishing nets and ropes are still being utilized in considerable quantities, owing to their low first cost, easy availability and ease of manufacture at the cottage industry level. According to an investigation carried out in 1952, some 40,000 tons of commodities made from straw are still utilized in the fishing industry alone.

Recently, in line with the policy of producing 'self-supplied fertilizer', there has been an increased demand for straw for this purpose. However, it is likely that the use of straw as manure will fall off with the manufacture of more effective chemical fertilizers, and it is therefore likely that rice straw will continue to be used for making ropes and nets so long as there are rice fields in Japan.

Coal tar has been widely used as a preservative for rice straw fishing nets and ropes and due to its excellent antiseptic qualities, the quantity of straw nets and ropes in use has considerably increased.

The following data refer to an experiment conducted on the use of straw, cotton and Manila nets in order to compare the number of days after which breaking strength decreased to half :—

of Material	No. of Strands	Diameter	Original Breaking Strength	No. of Days when Breaking Strength was Reduced to One Half
GO (straw) ..	2	4 mm.	20.4 kg.	24 days
GO (straw treated tar)	2	,,	19.5 ,,	102 ,,
-MIGO (straw)	2	4.5 ,,	24.5 ,,	54 ,,
-MIGO (straw th coal tar)	2	,,	23.6 ,,	210 ,, over
.. ..	2	4 ,,	57.6 ,,	21 ,,
(Cotton treated tar) ..	2	,,	48.5 ,,	210 ,, over
.. ..	2	3 ,,	58.5 ,,	60 ,,
Manila treated .. tar)	2	,,	45.8 ,,	141 ,,

Fishing Technologist, Tokai Regional Fisheries Research Laboratory, Tokyo, Japan.

It is a special characteristic of straw fishing nets, that there is some difference in the rate of putrefaction with the size of the ropes, and these differences are even more in evidence in relation to the number of twists in the ropes. The initial breaking strength of straw ropes which have many twists is w the degree of putrefaction is much smaller. more clearly shown in the following data experiment where tested ropes were imm water.

Name of Material	No. of Strands	Diameter	No. of Twists per feet	Weight per 5 feet	Breaking Point, (dry)	Breakin (w
AKITA-MIGO ..	2	5.6 mm.	16	35 gr.	25.4 kg.	24
ODAWARA-MIGO	2	4.4 ,,	56	10 ,,	20.0 ,,	1

With reference to the difference of breaking strength wet and dry a greater breaking strength is recorded for the dry material, which is contrary to experience in the case of cotton or hemp.

As regard to the dyeing of nets, coal tar is more economical than other substances. However, we were unable to obtain favourable results with blended dyeing of B.H.C., etc. Of course, the quantity of coal tar to be used for dyeing differs with the method employed. In lukewarm dyeing bath, about 2.5 litres of preservative was required per 10 lb. of straw materials. ' Migo rope ' is one of the ropes made of rice straw stalk alone and is the best among other straw ropes. At present there are many ropes manufactured by blending leaves of rice, among which we have ' hard twist ' and ' medium twist '. The individual strands are manufactured as a household industry and the fishermen twist them together to give the required sizes of rope for the fishing nets.

Straw ropes are also used without dyeing where it is desired to scare the fish, as in the wings of drag nets or leaders of set nets. The mesh used cases is extremely wide up to about

Name of Material	Diameter	B St
RICE STRAW ROPE Hard twist	7.6 mm.	1
Same, treated with coal tar	,,	
RICE STRAW ROPE Medium twist	9.0 ,,	
Same, treated with coal tar	,,	

Notwithstanding the fact that they rot aw rapidly and must be replaced about four times each season, it is reported that they an economic proposition.

19

DO FISHING LIGHTS AFFECT THE FISH POPULATION?

by

Z. Nakai*

an, lift net fishing for saury (*Cololabis* d round haulers for sardines (*Sardinops ta*) are representative types of gear which on a large scale to attract schools of their operation range. Since 1948, the as developed with great strides in northern the Pacific coast of Japan and the latter in use off the Kyushu coasts since sometime 2, when most fishing boats in the region ipped with electric facilities. The present s to show the relationship between the y of the fishing lamps (which has increased years) and fluctuations in the stocks of the leading up to a discussion as to the effects, such lights on the populations of saury nes in Japanese waters.

et Fishing for Saury.—The lift net held and aided with lamps for the fishing of technique of rather recent introduction. t had almost completely replaced the drift h till then had been the principal gear used ary fishery (Takayama, 1949). The great of the saury catch (about 94 percent of l total on a 1948-1954 average) is obtained articular type of gear off the Pacific coast from Chiba Prefecture, northward to

these seven seasons, the total light power saury fishing boats as well as the average r boat was increasing year after year ied by an increase in both total landings per boat. The number of boats operat- e fishery did not, however, increase in , and it is curious to note that the catch almost proportionally to the square of power. Taking the data for 1948 as the ber, in Table I the increase of catch in our times, whereas the light power (The power of fishing lights for the saury limited so as not to exceed 10 kw. a boat). s for 1948, used as the index number umber of saury fishing boats 988, regional oo metric tons, catch per boat, 62 tons.

ch during the period 1950 to 53 consisted ze fish with a mode of 27-28 cm. in the ribution. In 1954, however, the samples odal consisting of small-size group and a large-size one, 30-31 cm. in mode, the latter being no less in the catch than the former. From their scales the small-size fish were estimated to be three years old and the large-size fish four years based on the 1950 data obtained in morphometric surveys conducted by the Tokai and Tohoku Laboratories; data for 1951-54 by the Tohoku Laboratory and for 1952-54 by the Iwate Prefectural Fisheries Experimental Station. Data for 1950-51 by the Iwate Prefectural Station have been quoted from a report by Kasahara and Ozuru, 1952.

TABLE I

Annual Indices of Number of Boats, Catch, and Light-Powers for Saury Fishing, North Pacific Region, (1948 = 100)

Year	Number of Boats	Regional Light Power	Total Catch	Average Light Power	Catch Per Boat	Total Catch in Japan
1947	—	?	28	?	—	36
1948	100	100	100	100	100	100
1949	103	108	103	108	100	98
1950	129	144	192	115	148	192
1951	121	151	197	127	161	200
1952	119	173	344	149	287	344
1953	118	206	391	178	329	386
1954	122	217	458	184	372	444

If the small-size group (the majority of the 1953 catch) is really one year younger than the large-size one abundantly caught in 1954, both should belong to the same year-class. This is a problem calling for special attention in regard to fishing rate.

Now, on the basis of the above information on luminosity of fishing lights, catch, and length distribution (or age composition), it will be discussed as to whether or not the stock was on the decrease during these seven years under the influence of excessive fishing intensity, and whether or not the luminosity had detrimental effects upon the population. During the period under study, the amount of catch has generally been proportional to the square of fishing luminosity, which is indicative of the important role played by fishing lights in augmenting the catch. At the same time, when this and other biological factors such as the maturity of saury being reached in about three years (the catch mostly consisting of three and four-year-olds) are taken

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Biologist of Tokai Regional Fisheries Research Laboratory, Tokyo, Japan.

together into consideration, one might be led to believe that the fishing intensity during the period has not yet exerted an adverse effect upon the stock.

If the large-size group forming nearly one half of the 1954 catch belonged to the same year-class as the majority of the 1953 catch, the fishing rate in 1953 could not be excessively high. As shown in Table I, the farther one goes back prior to 1953, the fewer will be the catch in comparison with the 1953 yield.

Since the fish mature in three years, and the age of the catch in general is accepted to be three to four years, if the fishing rate had been so high as to impose an excessive pressure upon the stock, it would be most unlikely that such a tremendous increase in the catch as indicated in Table I should continue one season after another for the length of seven years.

The above assumptions should be substantiated with further statistics. Nevertheless, all the facts described above do not seem to support a view that the fishing intensity of saury lift net operations had up to 1953 depleted the population, and that the fishing luminosity caused physiological disturbance in the fish and increased the mortality, exerting an unfavourable influence on the abundance of the stock.

Round Haul Fishing for Sardine.—The waters adjacent to Kyushu are important fishing grounds for sardine. Round hauls have for many years operated at night with the aid of lights . As far back as the 1900's the fishermen in that region started to use torch lights with a luminosity of some 10 to 100 watts. Electric lamps, which came into general use in about 1920, gained prevalence among the round haulers by 1932. The brightness of the fishing lamps in that period was not more than 1 to 2 kw. and it was not until after World War II that the luminosity increased to about 3 kw. especially in 1950. More recently some of the fishing lights are reported to be 4 to 5 kw. and the range varies from 2 to 6 kw. depending on administrative regulations of different prefectures. At any rate, the fishing light used by the sardine purse seiners are not so powerful as those of saury lift net fisheries. There is sufficient evidence for the belief that the sardine population in the sea adjacent to Japan during 1949 to 1953 has been in stability as will be seen from Tables II-a-b.

TABLE II-a

Annual Indices of the Number of Adult Sardine Catch
(1949=100)

Age of Fish		1949	1950	1951	1952	1953
II Years Old	..	100	107	129	222	216
III Years Old	..	100	92	146	294	157
IV Years Old	..	100	154	127	174	380

Note :—

1. Data from 1949 to 1951 were prepa Nakai and Hayashi (1955) and data for 19 1953 were based on a fishing forecast of fishery by Nakai (1955).

2. The age composition of adult sardine base year 1949 2-years-old to be 292 m 3-years-old 203 millions ; 4-years-old 74 milli

TABLE II-b

Apparent Survival Rate of Sardine, II-III Years*
1949-53

Age of Fish		1949	1950	1951	1952
II Years Old	..	·26	·35	·41	·48
III Years Old	..	·69	·59	·68	·92

*Expressed in ratio of number of catch year-younger fish.

This evidence would hardly validate a vi the use of fishing lights of about 3 kw. has adverse effect upon the sardine populatio though a series of data pertaining to com landings and spawning fluctuations points considerable decrease in the sardine stock compared with what it was prior to the war, ness of fishing lamps, less than 1 to 2 kw. in the p period, may be exempted from possible ca the depletion in the abundance of the sardine p tion.

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20

SERVATIONS ON FISHING WITH LIGHT IN THE PHILIPPINES

by

S. B. Rasalan and B. Datingaling*

ABSTRACT

e of light in fishing is widely practised in pines. The earliest forms of light were ade from bundles of dried coconut or aves or split bamboos used on dark nights ction with hand-operated gear such as rs, cover traps, etc. for subsistence fishing seashores and in rivers and lakes.

troduction of kerosene for household fuel e use of kerosene torches made from illed bamboo tubes of about three feet h one end closed, the other being with a cotton rag wick. This bamboo used not only with hand-operated gear beaches but also with those operated on gouts operating farther from the shore. lamps with reflectors were later used to ter quantities of fish and these were in turn d in about 1924 by mantle lamps of 150 ndle power. Mantle lamps varying from 00 candle power are now being used by e fishermen, while commercial fishermen 47, vying for bigger catches had to resort of light with still higher candle power. t, motorized fishing boats are equipped ric generators capable of supplying enough rrent for eight to 16 bulbs of 1,000 watts

h light is used effectively in making a school of fish more compact so that they can easily be caught by nets, its use has given rise to certain objections from operators of purse seines, ring nets, fish corrals and other gear which are operated without the use of light. Purse seine and ring net operators claim that bright lights tend to divide the big schools of fish into smaller groups by making them go from one light to another of higher intensity, and that strong lights make it difficult to detect phosphorescence of the surface water which on dark nights indicates the presence of a school of fish.

In particular, the owners of fish corrals state that the fish which are moving towards the corral are attracted away if lights are operated closer than 200 metres.

It has also been argued that migrations into estuaries and lagoons are interrupted with the consequent possibility of depletion of the stocks. It is stated, for instance, that when lights are used during the northeast monsoon (November to April) in catching anchovies, herrings, sardines, mackerels and round scads at the entrance and approaches of the Malampaya Sound, these fishes cannot be found inside the sound, whereas, during the southwest monsoon (June to October) when the same fishing gear cannot be operated, these pelagic fishes are caught inside the sound.

On the other hand, the seiners, while not objecting to the use of kerosene lights, are opposed to the use of higher powered lamps.

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au of Fisheries, Manila, Philippines.

21

FISHING WITH LIGHT IN JAPAN

by

S. Takayama*

The use of light by burning plants or their roots to attract fish has been practised in night fishing from ancient times. With the discovery of petroleum, the kerosene lamp and the compressed kerosene lamp, these came to be used in nocturnal fishing operations. Subsequently, the electric light also has been used for this purpose. Electric lamps have the advantage of being used both above and under water, and so, various kinds of electric lamps have been applied for this purpose with reference to the phototaxic habits of the fishes. Even the fluorescent lamp and the mercury lamp have been tried; but these have not become popular because of the lack of proper equipment in fishing boats, or of technical know-how on the part of the fishermen. At present, ordinary electric bulbs are the most popular.

The electric fishing lights in a small boat are lighted by a battery of about 6 volts in voltage and 120 ampere-hours in capacity, or by a one kilowatt generator connected directly to the main engine. Those of the larger boats are operated by a 15 kilowatts generator driven by the auxiliary engine. Sizes of these lighting systems, of course, differ with the sizes of the fishing boat.

Studies on Fishing Lights.—To study the phototaxis of fish schools in Japan, several experimental fishing operations have been conducted, using light as an auxiliary fishing gear. Investigations on the physiological and psychological reactions of fishes have progressed in recent years. Stimulation and reaction of fishes to a certain wave-length of light differs not only in different species, but also in the same species in different environments. The investigation on the reaction of fishes to stimuli caused by different wave-lenghts of light, and to artificial combinations of stimuli needs highly complex experiments, and the results of such work are not yet available.

It appears that fishes gather to a light not only on account of their phototaxis. Considering the ecological groups of marine creatures gathered, it is seen that zooplankton is caught first, small fishes next, and finally large fishes. This order closely corresponds to the pattern of the food chain, and studies on the phototaxis of each of these groups are in progress.

On the basis that the phototaxis of fishes differs according to the contour lines of illumination water, blue light with shorter wave-length a absorption and scattering of light, is pre for the purpose of gathering fishes from a range by illuminating a greater area to a depth, while red light is probably the least ef for the opposite reason.

Of course, the optic sensitivity curve of does not necessarily coincide with that of beings, and the reactions of fish to stimuli of wave-lengths of light are varied. Results fr investigations on reactions of fish against in the experimental basin cannot be applied to wild fish schools. However, by means supersonic fish finder it has been recogniz the phototaxis of the sardine schools in waters is in the range around 10^{-2} lux da colour illumination.

Application of Light.—The application o of course, differs according to the conditions fishing ground. Generally, in regions o transparency, a smaller light source is su Various strengths of light sources are u accordance with the size of fishing operation instance, when fishing lights of uniform wave- are used from a one kilowatt source, in o gather widely distributed fishes which phototaxis, the following three methods are considered.

(1) The one kilowatt concentrated at one
(2) Two units of 500 watts each are used different places.
(3) Two units of 500 watts each at d places, and after the fishes collec unit moves gradually to the other, d the schools together.

When the absorption and scattering of light water is taken into consideration, the tw method is better. This method is adopted in seine and lift net fishing. When a strong l used, the fishes directly under the light begin t anti-phototaxis to the over-illumination and away to the moderately illuminated zone arou direct light. Sardine schools tend to act thus lux illumination under water. When a stron is used to gather the schools, the illumina properly regulated by gradually reducing th (use of the rheostat is not desirable) without ch

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* Chief Fishing Technologist, Tokai Fisheries Research Laboratory, Tokyo, Japan.

osition of wave-lengths, concentrating the
ore densely. In hand line fishing for
, the lures are used in combination with
l the combined stimuli have led to a great
n efficiency.

ing the duration of illumination, this
cording to the productivity of the fishing
Generally, about two hours of illumina-
be the maximum required. If within this
oals do not collect, the operation should
d to a different ground. Of course, where
shoals are not abundant, light may fail
a fish school in a short time.

o shade is usually employed to concentrate
of the bulb. However, deep lamp-shades
k shadows, owing to the rolling of the boat,
ng away the schools which have collected.
e light is placed higher above the water, it
inate a wider area. In this case, reflections
from the surface are taken into account.
on and scattering of light in the air, however,
an that under water. To illuminate a wide
surface water this method is preferable.
aury fishery with the stick-held net this
s adopted. When the light is placed lower,
inated part is narrower, but the illumina-
be intensified. This idea is applied to the
fishing of mackerels and horse mackerels.

rine light is advantageous in illuminating
fic part at a given depth where fishes cruise.
st, a special glove (cover) was used to protect
from water pressure. But the usual electric
l in stores is strong enough to resist the
ssure at 20 metres depth, if its joint with the
water-tight. The use of flint-glass for
is preferable from the standpoint of radia-
the bulb should be lighted up after sub-
According to experiments, in coastal
round Japan absorption and scattering of
ler water occurs to a high degree in the
rom the surface to one metre depth; there-
submarine light should be used beyond this
This idea is adopted in purse seining for
s and horse mackerels. The purse seine
a 600 metre float-line has been operated
lly with light of one or two kilowatts in
ng ground where transparency is 10 to
s. The proper intensity of illumination
ignificant.

ies Using Fishing Lights in Japan.—
ights are used in various fisheries ranging
e small scale horse mackerel handline
the large scale mackerel and horse mackerel
ne fishery, or the saury fishery with stick-
s.

one fourth of the over-all catch from marine fisheries in Japan is landed by fisheries operated with fishing lights. About 1,000 units in the sardine, mackerel, and horse mackerel purse seine fishery, 1,654 units in the saury fishery with stick-held lift nets, 15,818 units in the mackerel and horse mackerel angling fishery, and 48,484 units in the squid angling fishery, have used fishing lights. Most handline fishing boats for squids, mackerels, or horse mackerels are of very small tonnage, but equipped with lights, so that each fisherman uses a bulb of 50 to 500 watts.

In the purse seine fishery, one or two lighting boats are engaged exclusively for illuminating. In most cases, the boat uses the light both above and under water. The purse seining boat surrounds both the school and the illuminating boat. Where there are two lighting boats, while one boat is surrounded by the seining boat, the other boat usually shifts to another fishing ground.

In saury fishing with stick-held lift nets, the lights are used above water, arranged in several sets around the boat. Each set consists of about five bulbs of 500 to 1,000 watts which are combined together. These lights are switched on so as to gather schools from a wide range, and the number of lights is then reduced gradually to concentrate the schools, leading them to a position above the net.

Adverse Effects of Fishing Lights.—No adverse effects have been observed on eggs, newly hatched larvae, nor young stage of fishes. There is the possibility that the fishing lights if switched on at the time of breeding, may slightly influence nocturnal breeding activities. However, it has been observed that fish schools at the breeding stage have no phototaxis.

It is reasonable to increase fishing intensity by the utilization of fishing lights. To think that the fishing light is objectionable because it may lead to over-fishing or injury to young stages, seems to be unwarranted. The point is to ensure a rational balance between fishing intensity and the stock of fishes, operating area, etc.

Restriction of fishing lights in Japan is intended to protect small coastal fisheries. In some places, restrictions have been imposed not only on the intensity of the source of light and the number of bulbs used, but also on the operating area and fishing duration. There is a general restriction throughout the country on fishing lights for the saury fishing boats with the stick-held, lift nets, 10 kilowatts capacity and 20 pieces of 500 watts bulbs being the maximum permitted. This has been interpreted as an attempt to prevent the unnecessary increase in the intensity of the light used, through uncontrolled accumulative competition among the fishermen.

22

EXPERIMENTS WITH THE FISH GATHERING LAMP

by

N. Y. Kawamoto*

Fish lamps have been used since remote times in every region in the world to increase fish catches. In Japan, torchlight, which had been traditionally used for this purpose, has more recently been superseded by electric fish lamps which are now almost universally employed. However, maximum efficiency could not be expected because of unreliable theories about fish lamps. Some studies have been carried out regarding the effect of lamps upon fish shoals in the sea, but these were chiefly on the physical side and biological considerations were only partially taken into account. Hence, there has been no fundamental study of the reason for the methods of using lamps.

The writer has studied since 1947, with co-investigators, the relation between fish behaviour and fish lamps, using methods of physiology and experimental zoology. In these experiments, many kinds of juvenile marine fishes were used and their reaction to various kinds of light was studied in the dark room. Investigations were also carried out on the behaviour of adult horse-mackerel in a rectangular net which was set down off the coast facing the Ichthyological Research Institute, Shimoda, Izu Peninsula, Japan.

Experiments.—In the laboratory, the writer used a lustreless, black, round wooden tank, 100 cm. in diameter and 25 cm. in depth, and the tank was divided radially into eight compartments, which were open to each other at the center. The tank was filled with water to a depth of 20 cm. and a 10 cm. × 14 cm. colour filter was placed over a light window on the upper side of each compartment with 60-watt electric bulb set 20 cm. above each filter. In order to make the illumination for the colored lights equal to 50 lux on the water surface of each of the eight compartments, the luminosity was adjusted by placing some white papers over the filters. The colour filters were arranged in two ways, one in order of wave-length and the other at random in order that the fish might not become familiar withthe colour arrangements ; the frequency rates of individuals entering each compartment were then observed and compared with the relative energies calculated from the transparency of the filters, sensibility of the selen photometer and radiant energy of the lamps, and the tendencies to phototaxis were assessed therefrom.

From the results of these experiments, ph
of fish was found to be classifiable into tw
In the one, the greatest fish-gathering rates o
in the green and blue range of wave-lengths
seen in the cases of *Oplegnathus* (Parro
Monacanthus (File fish), *Scomberomorus* (Se
Spheroides (Tiger Puffer) and *Sphyraena* (Bar
while in the other type of phototaxis (e.g.
Eel) the opposite occurred.

The product of radiant energy of light of a
wave-length and the visual acuity of the eye
light was called the 'spectra luminosity' f
wave-length, and when the spectral luminos
calculated by using the visibility curve of
eye, it was seen that the ratio of the fish ga
rates for the two lights was proportional
ratio of the spectral luminosities of the two
and 'visual efficiency' was calculated from t
of spectral luminosity to radiant energy.
case of *Spheroides rubripes*, green light show
largest visual efficiency, followed by blue,
that of red light was smallest ; in fact, re
with a radiant energy 22 times that of gree
had a visual efficiency no more than 1/62 of
the latter.

The relation between the influence of mo
and the fish lamp upon the gathering rates o
was studied in the laboratory and in the op
In a black coated tank, 1 m. in diameter and
depth of water of 20 cm. a 20W electric bulb
the F-light (representing the fish lamp) wa
so as to throw its light horizontally in the
on one side of the tank, and another, call
M-light, which was comparable to moo
was attached 2 metres above the surface,
0.068 Lux on the surface (the light intensity
full moon on the surface of the sea was me
and found to be 0.06 to 0.07 Lux).

Under these conditions, the gathering r
fish to the F-light was calculated for fifteen m
at water temperature of 13°-14°C in the dark
and experiments on the gathering rates of
to the F-light under varying intensity of the M
in different species of fish showed that the g
ing rates of *Girella punctata* was almost the
either with one light or both, while those of *Pe*
japonica (Sweeper) was considerably less wi

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* Faculty of Fisheries, Prefectural University of Mie, Tsu-city, Japan.

ts than with one, while those of *Spheroides* ; coincided with that of *Pempheris* even le intensity of the M-light was varied. It erved that the gathering rates decreased in of the F-light according to the increase of of the M-light and the rate increased in of green colour of the F-light and decreased d field.

open sea experiments were undertaken as A rectangular net 20 m. × 6 m. × 3 m. was n off the coast about 200 metres from the ear the Ichthyological Laboratory and ten *us trachurus* (Horse-mackerel) about 16 ody length and 30 gm. in body weight were in the net at the time of each experiment.

ne side of the net, a fish lamp was fixed horizontally toward the other side one metre e surface and 20W, 60W or 100W electric ere used as a light source of the fish lamp, reen glass filter 18 cm. in diameter having a transparency from 500 mμ to 570 mμ and um wave-length of 530 mμ.

veather was frequently stormy during the nt, as this study was carried out from er to February of 1950 and difficulties were perienced in observing the phenomena in gh sea. The rate of night gathering at e 9.8 decreased to 77.8% compared with the e of gathering during dark nights and to 21% noon age 10.7. The rate becomes zero at e 11.8 when there was no appreciable reac- he fish to light. As the light intensity of e 11.8 was almost equal to that of moon it might be supposed that the fish would any reaction to the fish lamp in the period those two ages.

these experiments, it was observed that ering rates of fish differed according to 20W, 60W, or 100W bulbs were used and nsidered that the 20W electric bulb was most within the limits of the size of this experi- et, the rates of gathering becoming irregular t sources of 60W and 100W.

clearly seen that the effect of the fish lamp enced by moonlight both in the experiments laboratory and in the open sea; the author however that the efficiency of the fish ght be regulated by adjusting its intensity. tion of these intensities is not, however, iently studied, and will be ascertained in eriments.

course of these studies, it was also apparent efficiency of the lamp was considerably by phenomena such as tidal currents, of wind and temperature of sea water etc., and the relation of these important factors to the effect of the lamp will also be studied.

An experiment was later undertaken in order to observe the responses to light at various times of the day. Certain fishes, for example *Girella punctata* Gray, *Rudarius ercodes* Jordan et Fowler, show an extremely strong light-seeking tendency in daytime and a notable break-down of activity during the night. Using one white light, observations were made of the changes caused by the difference in the time of the day in the phototaxis of *Girella* (body length about 2 cm). The gathering rate for bright areas was high in the daytime, gradually becoming lower toward evening, and conversely that for dim areas increased as evening approached. From evening to midnight large numbers of fish appeared in the dim area, although the fish were relatively inactive and showed a tendency to keep away from the bright light.

To observe the rhythmicity in phototaxis for colored light, two colored lights (green and red) arranged at both sides of the tank were used and observations were made throughout one day. A strong light-seeking tendency for green light was observed during daytime (gathering rate 80-90%). A notable break-down of phototaxis for green light occurred in the evening, accompanied by a corresponding increase in the gathering rate for red light, which reaches its maximum in the middle of the night and the early hours of the morning while it is still dark. With the approach of sunrise, the fish became active and return to their daytime behaviour when, in view of the high spectral luminosity of the green light, it is natural that there should be a higher gathering rate than for red.

However, although the experiments indicated that the individual gathering rates of different species of fish to the fish lamp may be estimated under varying conditions of spectral luminosity, the influence of the diurnal rhythm of the species, the occurrence of fish food and predators around the fish lamp and other unknowns, still have to be taken into account.

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23

STUDIES ON THE BLEACHING AND UTILIZATION OF THE SEAW 'GULAMAN-DAGAT' (*GRACILARIA CONFERVOIDES*)

by

J. I. Sulit, L. G. Salcedo and P. C. Panganiban*

The annual occurrence of 'gulaman-dagat' seaweed (*Gracilaria confervoides*) in Philippine marine waters, especially along the shallow shores of Manila Bay, was first reported by Seale in 1911. The heavy season of this particular seaweed begins from January to the latter part of June every year. The report of Collado (1926) on the nutritive properties of seaweeds, mentioned gulaman-dagat as a possible source of commercial agar and food as well. The amount of gulaman-dagat, found annually along the shallow shores of Manila Bay is enough to supply a home industry for bleaching and drying the seaweed for commercial purposes.

During the Japanese occupation in World War II, gulaman-dagat was used extensively as food in the form of salad and dessert, a kind of preparation similar to various recipes made out of imported commercial agar. Likewise, De Leon *et al* (1947), reported that gulaman-dagat is definitely an ideal source of commercial agar. Also in 1951, Kojima claimed that the quality of agar prepared from *Gracilaria confervoides* is superior to others, and even exceeds the standard specified by the United States Pharmacopoeia. A year later, Sulit *et al* (1952), mentioned gulaman-dagat, among other seaweeds, as a potential source of commercial agar. However, in spite of the aforementioned properties of this particular marine plant product, there is no move whatsoever in utilizing it in the manufacture of agar in the Philipines. The main reason, perhaps, is the high cost of producing this important commodity in this country as compared with nations that can utilize the natural cold win freezing the solidified agar extracts. One methods used in the manufacture of dried requires freezing temperature to freeze the extract, so that drying is easily accomplished door in a comparatively short period.

Under Philippine conditions the authors ad the direct utilization of the bleached dried gula dagat in the preparation of various food pro purposely to create a home industry project in r where this seaweed is plentiful. Bleaching drying of the seaweeds may create a comm home industry in many fishing villages throu the Philippines. In this manner, importati commercial agar may be reduced.

The usual practice of bleaching and gulaman-dagat seaweed under direct sunlight at least three days.

The present study was undertaken to fin the best and quickest means of bleaching gula dagat by chemical methods and the utility product.

Gathering the seaweed.—Gathering the weed along the shallow shores of Manila Bay u starts in the early morning when the tide is It is estimated that at the peak of the season, than 1,000 tiklis[1] of seaweed is harvested. Each tiklis has an average net weight of thir kilograms of seaweed, and is being sold at ranging from ten to twenty-five centavos per ce depending on the distance or place of desti-

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* Bureau of Fisheries Manila, Philippines.

[1] A round rattan basket.

ual raking of the seaweed is a slow process n operate only at a depth under one fathom. crease the amount of harvest per man hour, rovised rake is often attached to an outboard This also enables, harvesting to cover areas even beyond one fathom. A collector bamboo basket goes around to each harvester llects the seaweed, which is in turn deposited iting 'banca' or dugout. As soon as the banca y loaded, it is towed to transport the sea- to prospective buyers, most of whom are d operators who use it as supplementary r the 'bangos', *Chanos chanos* (Forskal).

ching the seaweed.—Several experiments ndertaken on bleaching the seaweed. Kojima used hypochlorides of calcium and sodium fully in expediting bleaching. Potassium nganate and hydrogen peroxide were also y him ; but it took a longer time to accomplish sired effect with these than with the hypo- es.

atment with saturated calcium oxide n (calcium hydroxide).—In this study, ated solution of local material calcium oxide ed as a preliminary treatment in the sun- ng of the seaweed. The seaweed was soaked rated solution of calcium oxide for several s until the final color of the seaweed was reen. It was then spread on bamboo mattings istened occasionally to facilitate the bleaching. as the seaweed was thoroughly bleached it shed with fresh water and then dried in the On drying, the product turned light brown. hole process of bleaching and drying took 1½ epending upon the weather condition. Al- calcium oxide aids in shortening the time hing, the property of this chemical to harden ssues, toughens the seaweed, thereby making to extract the agar from it completely.

Treatment with sodium hypochlorite.—The sodium hypochlorite used in this study was prepared in the laboratory by passing chlorine gas to a 5 per cent solution of sodium hydroxide. The solution thus prepared was too strong for bleaching the seaweed. Hence it was diluted by using 1 : 10 up to 1 : 50 parts water. The color of the seaweeds was changed from dark green to olive or pea green. The treated seaweed was spread on bamboo mattings and occasionally moistened with water. As soon as bleached, the seaweed was washed with fresh water and then dried in the sun. With 1 : 10 and 1 : 50 dilutions, the length of time consumed was 20 minutes and 50 minutes, respectively. Although the length of time was shortened in converting the color of the seaweed to light green with the strong and 1 : 10 dilution of sodium hypochlorite, the gel strength of the agar extract prepared from the treated dried seaweed was found to be very low (Table II). The 1 : 50 dilution of sodium hypochlorite proved to be the best as shown by the gel strength of the agar extract prepared from it. Table II shows that the gel strength is slightly higher in the experiment conducted without the addition of sulphuric acid.

Extraction of agar.—The extraction of agar from the bleached, dried seaweed presents another problem. The use of inorganic acid was advocated by Tressler and Lemon (1951). Kojima reported that at a pH of 6.0 brought about by the addition of sulphuric acid, greater yield of high quality agar is produced. In the present study, various amounts of one-tenth normal sulphuric acid ($1/10$ N H_2SO_4) were used in the extraction of the agar.

For every 5-gram sample of the bleached, dried seaweed, 500 ml. of water, 5 ml. 10 ml. and 15 ml. of $1/10$ N H_2SO_4 acid were added and the resulting pH determined (Table I). All the experimental batches were boiled down to the same net weight before filtering into 100 ml. beakers set aside for use in the gel strength determination.

TABLE I

arative hydrogen-ion concentration of the dried, bleached gulaman-dagat (Gracilaria confervoides) soaked in water containing various amounts of $1/10$ N H_2SO_4

Treatment of Seaweeds	Hydrogen-ion concentration according to amounts of acid used			
	0 ml. Acid	5 ml. acid	10 ml. acid	15 ml. acid
	pH	pH	pH	pH
reatment (control)	7.49	6.58	6.23	3.17
rated calcium hydroxide solution . .	7.42	6.66	5.82	3.18
ng sodium hypochloride	7.46	6.58	5.75	3.23
um hypochloride (1 : 10)	7.56	6.44	5.52	3.05
um hypochloride (1 : 50)	7.20	6.41	5.60	3.27

Gel strength of solidified agar extracts.—In order to determine the quality of the extracted agar the solidified agar extracts contained in 100 ml. beakers were tested for their gel strength in an improvised apparatus. The gel strength was measured in terms of millilitres of water registered in a 100 ml. burette attached to a balance. cracking point made by the burette on th contained in the beaker constitutes the gel str of the agar extracts (Table II). The gel str was seen to be poor, ranging from 2.40 to 8.

TABLE II

Gel strength in millilitres of water of agar extracted from the dried bleached gulaman-dagat with various amounts of 1/10 NH

Treatment of Seaweeds	Gel strength of extracted agar			
	0 ml. acid	5 ml. acid	10 ml. acid	1 ac
1. No treatment (control)	17.1	13.8	14.2	20
2. Saturated calcium hydroxide solution ..	2.40	5.75	8.10	7.
3. Strong sodium hypochlorite solution ..	10.20	7.10	3.30	3.
4. Sodium hypochlorite (1:10)	15.80	8.50	5.30	5.60
5. Sodium hypochlorite (1:50)	27.70	25.20	26.40	26.70

Preparation of nutrient agar.—The imp bacto-agar is an expensive item in the preparation of nutrient agar solution. Bacto-agar was prepared by using the bleached, dried gulaman-dagat seaweed. To 14.25 grams of the bleached dried seaweed, 500 ml. of water was added; boiled for ten minutes and then filtered through cheesecloth. To every 200 ml. of the filtrate were added the following:

Peptone	1.25 grams
Bacto-beef extract	0.75 ,,
Sodium chloride	2.00 ,,

The mixture was heated to dissolve all the ingredients, the pH adjusted to 7.3, transferred to test tubes for purposes of plating and slants and then autoclaved for 15 minutes at 221°C. (15 lb. pressure). The nutrient agar thus prepared was satisfactory for plate count of bacteria in the micro-biological laboratory.

Preparation of dried agar similar to imp commercial agar.—To 25 grams of bleached gulaman-dagat, 875 ml. of water was adde then it was acidified by adding 20 ml. of 1 H_2SO_4 acid. The mixture was boiled for 30 m and then strained through cheesecloth. The r was treated with 250 ml. of water ; acidified w ml. of sulphuric acid ; heated to boiling ; an strained. After combining the first and s extracts, the mixture was allowed to solid moulds. The agar was then cut into strips half inch, and then set aside to freeze i refrigerator. The next day the frozen aga thawed and dried outdoors.

The prepared, dried agar was analyzed chen and it compared well with the chemical a of the imported agar (Table III).

TABLE III

Comparative chemical analysis of various brands of agar

Proximate chemical composition	Gulaman-dagat agar	Korean agar	Japanese agar	American
	Per cent	Per cent	Per cent	Per ce
Moisture	8.57	15.25	19.60	18.41
Ash	3.92	1.17	2.90	3.20
Protein (N x 6.25)	5.28	6.25	4.23	1.12
Nitrogen free extract	0.17	0.20	1.08	0.19

man-dagat recipes.—A few preparations ade using directly the bleached, dried -dagat. The basic materials and the pro- of each are as follows: 25 grams of the ; 4 cups of water; 3/4 cup of sugar and 1/2 milk (coconut or cow's milk). Fruits and gredients were added to improve the flavor desserts. A panel of tasters favorably d the wholesomeness of these preparations.

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REPARATION OF 'GALONGONG' (*DECAPTERUS MACROSOMA*) FISH MEAL AND ITS NUTRITIVE VALUE

by

O. N. Gonzalez,* S. V. Bersamin* and J. I. Sulit*

manufacture of fish meal from various species of minor commercial importance might help the amount of fish meal importation into untry. In view of the increasing poultry estock industries, our fish meal importation ,754 kilograms in 1949 was increased 2,041 kilograms in 1953, showing an increase oximately 700 per cent in a period of four In spite of this importation and the great fish meal, not much work has been done in nufacture of this product in this country. ay be due to lack of practical knowledge of inique of fish meal manufacture or of information on the utilization of the product.

use of the high protein and low crude fibre fish meals have been known (Nelson 1951) valuable in the feed of poultry and other . Petersen *et al.* (1952) reported that with meal in the ration of poultry, the maximum ility was obtained. The old method of fish meal by direct flame process has been aged because high temperature lessens the e value of the product. Pottenger *et al.* claimed that drying of fish meal at high ture destroys the most important essential cids, namely, tyrosine, tryptophane and Clandinin (1949) revealed that fish meals vacuum at 10 or 16 inches have very much nutritive value than those dried by the heat of 220°F.

The aim of the present work has been to develop the heat methods of preparation of fish meal adaptable for home industry in fishing centres, and determining the comparative nutritive value of the corresponding fish meals by means of chemical and bio-assay studies.

Preparation of fish meals.—The galongong (*Decapterus macrosoma*) was chosen because of its high protein and low fat content (Sulit *et al.* 1953) and because of its abundance in many of the Philippine marine waters, being one of the cheapest kind of fish found in the market. Twelve kilograms of the fresh fish were divided into three parts of four kilograms each. The first portion was cut into small pieces and then dried directly at 45°-60°C. When thoroughly dried the product was ground, weighed and placed in an air-tight container. The second and third portions were steamed for thirty minutes, after which they were reduced to small pieces and then dried at 45°-60°C. When thoroughly dried the fish meal was ground, weighed and placed in air-tight containers.

Preparation of the concentrated fish liquor.—The expressed liquor resulting from the steaming process of the second set of galongong was concentrated to 50 per cent of its original volume to produce a thick syrup. This product is similar to the fish soluble concentrate which is known to contain the vitamin B_{12} and the growth promoting compound

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* Bureau of Fisheries, Manila, Philippines.

(Bohstedt, 1950; Singsen, 1952; Tiliman *et al.* and Pensack *et al.* 1949).

The fish meals and the concentrated fish liquor prepared according to the aforementioned methods were analyzed chemically for their protein, fat, carbohydrates (calculated by difference), ash and mineral content (Table II). The value for growth studies of the products was determined by utilizing the biological method. The percentage (Table I) yields of the products were also recorded.

Physical properties of the fish meals and concentrated fish liquor.—The color of fish meal prepared from raw galongong is slightly darker than that processed by the steam method. The former has a slight putrid odour, which could be attributed to the partial decomposition of the fish during the process of drying. The color of the fish meals prepared by the steam method is light brown and it exhibits a characteristic fishy odour. The physical appearance of the latter is very much better than the former.

The concentrated fish liquor obtained by dehydration is a thick syrup, dark brown in color and having the usual predominating fishy odour.

Chemical analysis.— As shown in Table I, the percentage yield of fish meal prepared from raw galongong is 26.87 per cent as compared with 22.39 per cent in the steam-cooked product. The amount of concentrated fish liquor produced is 9.86 per cent.

Table II shows the proximate chemical composition and mineral analysis of the fish meals and the concentrated fish liquor. The protein content of the two fish meals of galongong are extraordinarily high, considering the fact that there is still an ideal amount of 5 per cent moisture in the final products. The protein content of the prepared concentrated fish liquor is slightly lower. However, a similar product, the fish soluble concentrate, is known to contain the growth promoting factor needed in the poultry and livestock industry (Petersen *et al.* 1952). The calcium and phosphorus contents of the raw fish meal are slightly higher than those of the steam-cooked fish meal.

Bio-assay.— Thirty albino rats of about the same weight were selected for the bio-assay. When the rats were about 28 to 30 days old, litter mates were divided into three groups of ten rats each, such that there would be a good distribution of males and females, and the total group weights would be about the same. The experimental diets were prepared so that the final composition contained 18 to 20 per cent protein derived from the fish meals and the added concentrated fish liquor in the amount of 2 per cent of the mixture or the diet (Tables II and III).

The rats were placed individually in s cages with raised screen bottoms provide paper towels to prevent the loss of spilled Ordinary room temperature was maintained th out the bio-assay period. Periodic weights recorded, and observations on the health abnormal developments of the rats were made

Table III shows the composition of the expe tal diets used. The fish meals and concentrat liquor constituted the major source of prot feeding the experimental rats and water was *ad libitum.*

As shown in Table IV or Figure 1, the a increase in weight of experimental rats fed raw galongong fish meal is significantly h

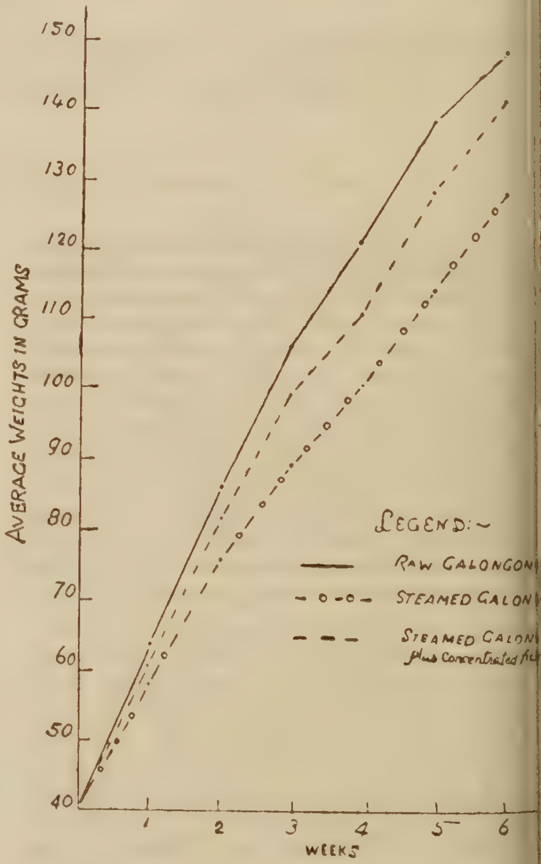

FIG. 1. Average weekly weights of rats fed with d diets.

evidenced by the weekly gain in weights. followed by the increase in weight of rats fed steam-cooked galongong plus 2 per cent o concentrated fish liquor. The third best shown by rats fed with steam-cooked fish m e rats fed with the three kinds of fish meals no indication of abnormalities as they are ood health, as shown by their active move- All the experimental rats at the end of the ents have well rounded and plumb bodies nificantly clear eyes.

ussion.— Sulit *et al.* (1953) reported that ng contains approximately 72 per cent of ortion. The present study revealed that nanufacture of galongong fish meal, a yield ximately 25 per cent was obtained.

Of the three kinds of fish meals prepared raw galongong fish meal gave, as shown above, the highest rate of growth, followed by steamed galongong fish meal plus the concentrated fish liquor and thirdly by the steamed galongong fish meal alone.

Because of the putrid smell of raw galongong fish meal, it is recommended that preliminary steaming of the fish be undertaken before drying. It is further recommended to add at least two per cent of the concentrated liquor to the fish meal to improve its nutritive food value.

TABLE I

The percentage yield of fish meal and concentrated fish liquor

Products	Per cent
Raw fish meal galongong	26.87
Steamed fish meal galongong	22.39
Concentrated fish liquor	9.86

TABLE II

The proximate chemical composition and mineral content of galongong fish meals and the concentrated fish liquor

	Raw galongong	Steamed galongong	Concentrated fish liquor of galongong
	Per cent	Per cent	Per cent
.. ..	74.17	75.04	70.08
.. ..	6.74	9.54	2.21
rates ..	.33	.08	.12
.. ..	13.05	9.99	8.57
.. ..	5.26	5.35	19.02
.. ..	4.08	3.37	.39
us	2.14	1.83	.67

TABLE III

mposition of experimental diets using the corresponding amount of fish meals and concentrated fish liquor

	Group I	Group II	Group III
	Per cent	Per cent	Per cent
rch ..	68	69	69
..	3	3	3
hloride ..	1	1	1
carbonate ..	2	2	2
..	2	2	2
oil ..	4 drops	4 drops	4 drops
al (raw galongong) ..	24	—	—
l (steamed galongong) ..	—	23	21
ated galongong fish ..	—	—	2

TABLE IV

Showing the average weekly weights of rats fed with different diets mentioned in Table III.

No. of Rats	Protein Supplement	Initial Weights	Weekly Average Weights						Avera increa in weig
			1	2	3	4	5	6	
		gm.	gm.	gm.	gm.	gm.	gm.	gm.	
10	Raw galongong ..	41	63.4	85.6	106.4	120.8	138.4	147.7	107
10	Steamed galongong ..	41	58.9	75.1	89.0	100.9	114.3	127.2	86
10	Steamed galongong-plus 2 % concentrated fish liquor ..	31	60.8	82.1	99.4	111.9	128.9	142.7	102

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25

TE SUR LA CONSERVATION DU POISSON SALE-SECHE SOUS EMBALLAGE DE POLYETHYLENE

par

R. Lafont*

sson salé séché produit au Cambodge
ne forte proportion deau (de 25 à 45%
espèces), et de 10 à 20% de Chlorure de

connu que dans un tel milieu, les bactéries
leur activité si la température est
à 10-15°. Comme au Cambodge la
e moyenne d'entreposage du poisson
est aux environ de 30°, l'activité
e peut atteindre un taux élevé. Cette
ctérienne a pour effet de produire une
on des proteines s'accompagnant d'une
de gaz volatils : ammoniac,
mine.

le développement des bactéries halophiles
e nul aux températures inférieures à 5°
salé séché peut être conservé dans de
nditions à des températures variant de
dant UN AN et plus.

n de pêche, et en particulier la période
roduction de poisson salé séché, ne dure
lge que quelques mois avec un maximum
uillet (60% de la production) et un mini-
ût à Décembre (12% de la production).
e une variation des prix inverse : baisse
Juillet, Hausse de Août à Janvier. Il
c intérêt à stocker une partie des quantités
Avril à Juillet pour les mettre sur le
ur et à mesure des besoins pendant les
t à Janvier.

age en entrepot non conditionné est
pendant cette période qui correspond à
es pluies, le poisson ayant tendance à se
ce qui favorise le développement des
ns putrides. En effect le sel, très
que, fixe l'humidité de l'air dès que son
degré Hygrométrique dépasse 72,5. Or de Juillet à Novembre le degré Hygrométrique moyen à Phnôm-Penh varie entre 80 et 90%. Nous avons essayé le stockage du poisson salé séché à basse température.

Resultats.

1°/Si du poisson salé séché est placé dans un entrepot à basse température non conditionné, l'air sec déshydrate le poisson jusqu'a l'amener à complète siccité ; le poisson semble cuit par le sel et n'est plus comparable au poisson salé séché de qualite commerciale.

2°/Pour éviter cette dessication du poisson nous l'avons isolé du contact de l'air en le placant dans un emballage étanche, imperméable à l'air.

Nous avons utilisé avec succès des sacs en polyèthylène soudés à chaud. La dessication est alors nulle.

La dessication a été complètement arrêtée, a tel point qu'après 6 Mois de stockage à 5° le poids de l'échantillon n'a pas varié de 0,3 %.

La qualité du poisson salé séché a la fin de l'expérience était parfaite ; nous n'avons pas remarqué d'odeur ou de gout de rance, ce qui tendrait à prouver que oxydation des graisses se trouve ralentie.

Un échantillon témoin conservé à la même température sans être emballé dans un sac de polyéthylène a perdu 34% de son poids (soit la presque totalité de son humidité) et n'était plus consommable.

Les sacs se Polyéthylène peuvent être récupérés après stockage dans la proportion de 90% et peuvent servir à une nouvelle opération l'année suivante Aussi les frais supplémentaires entrainés par ce mode d'emballage ne sont ils pas très très élevés.

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eur Chemiste Licencie es Sciences, Chef du Laboratoire de Technologie de l'Institut National des Recherches
Cambodge, Phnom Penh, Combodge.

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26

CHEMICAL PRESERVATION OF MARINE PRODUCTS

by

S. Tetsumoto,* T. Okitsu* and M. Fukuta*

Although various chemicals have been used in the preservation of food, such as boric acid, salicylic acid, para hydroxy butyl benzoate, Na-nitrite, and Na-hypochlorite, the preservation of raw marine products still presents many problems. The preservation by Na-nitrite for food is permitted by law in several countries, but is prohibited in Japan. Moreover, this chemical is only a weak preservative.

We studied the effect of nitrofuran compounds on putrefactive bacteria, such as *B. subtilis*, *B. mesentericus* and *Ps. vulgaris*, and confirmed that they have a strong sterilizing action besides being tasteless and odourless. They are harmless to health even if food preserved with them is used continuously for as long as three months. Dehydro acetic acid and vitamin K_3 were also observed to have strong sterilizing effect on putrefactive bacteria and to be tasteless and odourless and harmless to health. The details of the study are as given below:

Preservatives and concentration

5-NO_2-2-furfural semicarbazone (F.) ..	0.01%
5-NO_2-2-furfural acrylamide (Z.F.) ..	0.01%
3-acetyl-6-methyl-2H-pyran-2.4 (3H)-dione (dehydro acetic acid) (D.H.A.) ..	0.05%
2-methyl-1.4-naphthoquinone (vitamin K_3) (V.K_3) ..	0.02%
p-hydroxy butyl benzoate (P.B.) ..	0.02%
Boric acid (B.) ..	0.02%
$NaNO_2$ ..	0.02%

F. 0.01%aq 50 cc+D.H.A. 0.1% aq 50 cc
F. 0.01%aq 50 cc+V.K_3 0.02% aq 50 cc
F. 0.01%aq 50 cc+P.B. 0.02%aq 50 cc
D.H.A. 0.05%aq 50 cc+V.K_3 0.02%aq 50 cc
D.H.A. 0.05%aq 50 cc+P.B. 0.02%aq 50 cc
V.K_3 0.02%aq 50 cc+P.B. 0.02%aq 50 cc
F. 0.01% 50 cc+$NaNO_2$ 0.02%aq 50 cc
D.H.A. 0.05% 50 cc+$NaNO_2$ 0.02%aq 50 cc

Solvent sterilized	NaCl 0.85%aq
Control	NaCl 0.85%aq

Method of preservation

Three to four kilograms each of the washed marine products were put into a clean glass vessel and three to four litres of one of the preservative solutions mentioned above was added and shaken frequently. After 30 minutes, we poured preservative and left the marine products room. The preservation temperature was for fish, and 5-10.5°C for oyster. The was practically saturated. The extent of tion was tested daily for a week.

The extent of the preservation was judge results of quantitative analysis of bacteria, basic N, the pH of the product at the tim and organoleptic factors such as the degree factive odour, change in the colour of t eyes, head, gills etc., degree of elasticity of t turbidity of extracted body fluid and its palatability. For shrimp, it is very difficult the discolouration of eyes, and the degree of of the musculature, and so the denature culation was observed and for oyster, the c external appearance.

Experiments

I. *Effect of the preservatives on the mult of putrefactive bacteria in tuna and oyster*

A quantity of the preserved material was with agar medium by the normal metho total number of bacteria and also the g bacteria such as *Achromobacter*, *Fla* *Pseudomonus*, *Serratia*, Mould and Yeast, a forming bacteria were observed. The re given in Tables I and II.

The following findings were obtained as of the above experiments:

1. Within the range of 0.02-0.002% in the concentration of NO_2-furan co does not affect their arresting action multiplication of putrefactive bacteria and oyster meat.

2. The NO_2-furan compounds have strong sterilizing action on *Achrom* *Flavobacters* and *Serratias* groups, but *fluorescens* their action is very weak.

3. 0.05% of D.H.A. aqueous solution solution of vitamin K_3 and *p*-hydrox benzoate have relatively stronger sterilizi on *Ps. fluorescens* than NO_2-furan comp

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* Tokai Regional Fisheries Research Station, Tsukishima, Tokyo, Japan.

O_2-furan compounds have a strong steriliz- n on spore forming putrefactive bacteria *B. subtilis* and *B. mesentericus*, but the eservatives have very little effect on spore bacteria.

me preservatives have special effect eria. By NO_2-furan compounds, we ntrol Gram positive and spore forming and by other preservatives such as K_3, D.H.A. and $NaNO_2$, we could *. fluorescens* and other several putrefactive

he use of mixed preservatives with properties was most effective in prevent- increase of various putrefactive bacteria marine products.

ct of preservatives on volatile basic N of products.

atile basic N was measured by Folin's The results obtained are shown in Tables /. The following were the indications:

ithin the range of 0.02-0.002%, the ation of NO_2-furan compounds does t their retarding action on the increase of asic N of tuna and oyster meat. By 0.01% of NO_2-furan compounds, tuna meat preserved for about 28-36 hours. The putrefied within about 18 hours.

B. is comparatively more effective the increase of volatile basic N than acid. These well known preservatives weak in preventive power, and almost or the fishery purpose.

e use of mixed preservatives is more in retarding the production of volatile than use of any single preservative.

low the following concentrations, the tives appear to be ineffective against the of volatile basic N of raw marine products.

uran compounds 0.001%; D.H.A. %; V.K_3 0.005%; P.B. and Salicylic d 0.005%; Boric acid 0.2%.

fect of the preservatives on the pH changes rine products.

was measured by the electric-method.

At the beginning of putrefaction of fish, l other meat the pH was seen to be 6.5, the oyster, the pH at the beginning of putrefaction was 4.8. The results obtained are noted in Table V. These experiments revealed that:

1. The action of the preservatives on the pH changes in tuna and oyster is nearly almost similar to those of volatile basic N.

2. Within the range of 0.02-0.002%, the concentration of NO_2-furan compounds does not affect their action concerning pH changes in tuna and oyster.

3. Use of mixed preservatives is more effective than the use of any one of them.

4. Below the following concentrations, the preservatives are ineffective as regards pH changes.

NO_2-furan compounds 0.001%; D.H.A. 0.002%; V.K_3 0.005%; P.B. and salicylic acid 0.01%; Boric acid 0.2%.

It has been observed that above 0.02% concentration $NaNO_2$, *p*-hydroxy butyl benzoate and salicylic acid have slightly stronger action on bacteria than NO_2-furan compounds, but their action weakens below that concentration.

5. Following preservatives are practically ineffective for raw marine products:

0.01% aq solution of $NaNO_2$, *p*-hydroxy butyl benzoate and salicylic acid, 0.2% aq solution of boric acid, 0.01 % aq solution of D.H.A.

6. For the preservation of raw marine products, the use of mixed preservatives such as F.+V.K_3, F.+D.H.A., F.+$NaNO_2$ and V.K_3+D.H.A+. V.K_3; $NaNO_2$ were the best.

IV. *The effect of preservatives on keeping quality of raw marine products.*

For commercial purposes, raw marine products have to be preserved in the round condition.

The results of organoleptic observations in the preservation of raw marine products, are given in Table VII.

Summary

1. In summer, round raw marine products could be preserved for about 18-28 hours longer by the use of mixed preservatives such as F.+V.K_3, F.+D.H.A., F.+$NaNO_2$, V.K_3+.D.H.A. and V.K_3+$NaNO_2$ than without any preservative.

2. *p*-hydroxy butyl benzoate, salicylic acid and boric acid have hardly any effect in preserving round raw marine products.

TABLE I

Effect of preservatives on bacteria in tuna meat at 22-30.5°C

Time (hour)	1 h		24		72		1	24	72
	Number of micro organisms	Difference from control	Number of micro-organisms	Ratio to control	Number of micro-organisms	Ratio to control	Spore %	Spore %	Spore %
Control	2.3×10^3	Decreased numbers	3.6×10^6		5.5×10^{10}		5.6	7.0	12.3
F.	1.8×10^3	5×10^2	2.5×10^4	1/140	4.8×10^7	1/1146	2.7	2.3	2.8
Z.F.	1.6×10^3	7×10^2	1.5×10^4	1/240	1.8×1	1/3056	1.6	1.5	2.1
D.H.A.	2.1×10^3	2×10^2	4.8×10^4	1/75	6.9×10^7	1/798	3.3	6.8	9.8
$V.K_3$	2.0×10^3	3×10^2	4.4×10^4	1/82	6.6×10^7	1/833	2.8	4.9	9.1
P.B.	1.8×10^3	5×10^2	1.2×10^4	1/3	9.8×10^7	1/5.6	5.3	8.3	11.9
$NaNO_2$	1.8×10^3	5×10^2	1.2×10^4	1/3	6.9×10^7	1/798	4.3	6.3	10.8
B.	2.3×10^3	0	3.6×10^4	1	5.5×10^{10}	1	5.6	7.0	12.3
F. + D.H.A.	1.4×10^3	9×10^2	9.8×10^3	1/367	8.6×10^6	1/6395	2.2	2.1	2.1
F. + $V.K_3$	1.3×10^3	1×10^3	8.6×10^3	1/419	8.3×10^6	1/6627	2.2	1.9	2.0
F. + P.B.	1.5×10^3	8×10^2	1.3×10^4	1/277	9.2×10^6	1/5978	2.2	2.4	2.7
F. + $NaNO_2$	1.4×10^3	9×10^2	9.8×10^3	1/367	9.2×10^6	1/5978	2.2	2.4	2.7
D.H.A. + $V.K_3$	1.4×10^3	9×10^2	1.0×10^4	1/360	8.6×10^6	1/6395	2.5	2.2	2.8
D.H.A. + P.B.	1.4×10^3	9×10^2	1.4×10^4	1/257	9.4×10^6	1/5851	3.4	3.8	4.0
D.H.A. + $NaNO_3$	1.4×10^3	9×10^2	1.0×10^4	1/360	9.4×10^6	1/5851	3.4	3.8	4.0
$V.K_3$ + $NaNO_2$	1.4×10^3	9×10^2	1.0×10^4	1/360	9.2×10^6	1/5978	3.4	3.8	4.0

Time (hour)	1		24		72		1	24	72
Preservative	Number of micro-organisms	Difference from control	Number of micro-organisms	Ratio to control	Number of micro-organisms	Ratio to control	Spore %	Spore %	Spore %
Control	1.5×10^{6}	Increased number	9.0×10^{6}		6.0×10^{10}		9.5	10.4	11.4
F.	1.0×10^{6}	5.0×10^{5}	1.0×10^{6}	1/9	8.5×10^{7}	1/706	4.9	2.6	3.0
Z.F.	8.8×10^{5}	6.2×10^{5}	9.5×10^{5}	1/9.5	5.2×10^{7}	1/1156	2.8	2.3	2.8
D.H.A.	1.2×10^{5}	3.0×10^{5}	3.2×10^{6}	1/2.8	2.3×10^{8}	1/281	7.4	6.1	9.3
V.K_3	1.1×10^{6}	4.0×10^{5}	2.6×10^{6}	1/3.5	2.1×10^{8}	1/286	7.2	6.2	8.6
P.B.	1.2×10^{6}	3.0×10^{5}	4.8×10^{6}	1/2	3.8×10^{8}	1/16.4	9.4	10.7	11.4
$NaNO_2$	1.2×10^{6}	3.0×10^{5}	3.2×10^{6}	1/2.8	3.8×10^{8}	1/16.4	9.4	10.2	11.4
B.	1.5×10^{6}	O	9.0×10^{6}	1	6.0×10^{10}	1	9.5	10.4	11.4
F.+D.H.A.	7.5×10^{5}	7.5×10^{5}	9.4×10^{5}	1/9.6	4.5×10^{7}	1/1333	4.8	1.7	3.5
F.+V.K_3	6.6×10^{5}	8.4×10^{5}	8.6×10^{5}	1/10.5	3.2×10^{7}	1/1875	2.7	1.8	3.8
F.+P.B.	8.6×10^{5}	6.4×10^{5}	9.8×10^{5}	1/9	4.4×10^{7}	1/1364	3.6	3.3	3.4
F.+$NaNO_2$	6.6×10^{5}	8.4×10^{5}	8.6×10^{5}	1/10.5	4.4×10^{7}	1/1364	3.6		3.9
D.H.A.+V.K_3	7.6×10^{5}	7.4×10^{5}	9.3×10^{5}	1/9.7	5.3×10^{7}	1/1132	5.0	3.3	5.9
D.H.A.+P.B.	7.8×10^{5}	7.2×10^{5}	1.1×10^{6}	1/8.2	4.8×10^{7}	1/1250	5.7	5.0	6.7
D.H.A.+$NaNO_2$	7.8×10^{5}	7.2×10^{5}	1.1×10^{6}	1/8.2	4.8×10^{7}	1/1250	5.7	5.0	6.7
V.K_3+$NaNO_2$	7.6×10^{5}	7.4×10^{5}	9.3×10^{6}	1/9.7	5×10^{7}	1/1132	3.6	4.6	6.4

Table III

Effect of preservatives on volatile basic N of tuna meat at 23-31°C. Volatile basic N of original meat 18 mg.%

Data indicate mg. of volatile basic N in 100 g. of each material

Control	0.02%				0.01%				0.002%				0.001%			
Time (day) Preservative	1	2	3	5	1	2	3	5	1	2	3	5	1	2	3	5
Control	35	84	187	217	35	84	187	217	35	84	187	217	35	84	187	217
F. ..	24	28	70	180	24	28	70	180	28	32	77	187	32	56	114	203
Z.F. ..	21	24	63	175	21	26	66	175	24	28	70	180	28	49	112	203
D.H.A. ..	24	35	84	187	28	42	98	196	28	49	140	217	35	70	148	217
V.K$_3$ ..	24	35	77	187	24	35	91	196	24	35	133	194	35	70	140	217
P.B. ..	32	63	112	187	32	70	140	217	35	70	140	217	35	84	187	217
NaNO$_2$ ..	24	35	91	194	28	84	187	210	35	84	187	217	35	84	187	217
B. ..	35	84	187	217	35	84	187	217	35	84	187	217	35	84	187	217
F. + D.H.A. ..	21	24	49	140	21	24	49	147	21	28	70	147	28	35	98	180
F. + V.K$_3$ ..	21	24	42	140	21	24	42	140	21	28	63	140	28	35	77	168
F. + P.B. ..	21	24	56	147	21	24	63	147	28	32	77	147	28	42	112	203
F. + NaNO$_2$ ..	21	24	56	140	21	24	70	196	28	32	84	147	28	38	112	203
D.H.A. + V.K$_3$ ..	21	24	49	147	24	28	56	147	24	28	77	168	28	42	98	189
D.H.A. + P.B.	24	28	56	154	24	32	63	154	24	35	77	194	32	49	114	196
D.H.A. + NaNO$_2$	21	24	56	147	28	32	77	194	28	32	84	194	32	49	115	187
V.K$_3$ + NaNO$_2$ ..	21	24	49	140	28	32	63	154	28	32	77	187	32	49	84	180

Effect of preservatives on volatile basic N of oyster meat at 5-10.5°C. Volatile basic N of original meat 7 mg.%

Control	0.02%					0.01%					0.002%					0.001%				
Time (day) Preservative	1	2	3	5	7	1	2	3	5	7	1	2	3	5	7	1	2	3	5	7
Control	14	21	35	56	70	14	21	35	56	70	14	21	35	56	70	14	21	35	56	70
F. ..	10.5	17	24·5	35	56	10.5	17	24.5	35	56	11	17	25	38	63	14	17	28	49	67
Z.F. ..	10	14	21	24.5	52.5	10	14	21	25	53	11	14	21	32	56	11	17	24	42	63
D.H.A. ..	10.5	21	28	42	63	11	18	35	49	70	14	21	32	49	70	14	21	35	56	70
V.K$_3$ ..	10.5	21	28	42	59	11	18	28	42	63	14	18	28	42	67	14	21	35	56	70
P.B. ..	14	21	35	56	70	11	21	35	56	70	14	21	35	56	70	14	21	35	56	70
NaNO$_2$ ..	10.5	21	28	49	63	11	21	35	56	70	14	21	35	56	70	14	21	35	56	70
B. ..	14	21	35	56	70	14	21	35	56	70	14	21	35	56	70	14	21	35	56	70
F.+D.H.A. ..	7	14	18	28	53	7	14	21	28	53	7	14	21	31	56	11	21	24	53	70
F.+V.K$_3$ ..	7	14	18	28	49	7	11	18	28	49	7	14	18	28	52	11	17	21	42	63
F.+P.B. ..	11	14	24	32	53	11	14	21	42	56	11	14	23	32	63	11	17	24	49	70
F.+NaNO$_2$ ..	7	11	21	28	56	7	14	21	28	58	7	14	21	35	63	11	17	27	42	63
D.H.A.+V.K$_3$ ..	7	11	21	32	63	7	14	28	35	63	7	18	28	35	70	11	17	27	49	70
D.H.A.+NaNO$_2$	11	14	21	35	63	11	18	28	35	63	11	21	32	42	70	11	21	32	56	70
V.K$_3$+P.B. ..	11	14	21	35	70	11	14	21	45	70	11	14	27	45	70	11	14	27	53	70
V.K$_3$+NaNO$_2$ ..	7	11	21	32	63	7	14	21	35	63	7	18	28	35	70	11	17	27	49	70

TABLE V

Effect of preservatives on the change of pH of tuna at 23-31°C. Original pH of tuna meat 5.8.

Control	0.02%				0.01%				0.002%				0.001%			
(Time day) Preservative	1	2	3	5	1	2	3	5	1	2	3	5	1	2	3	5
Control	6.5	6.7	6.9	7.1	6.5	6.7	6.9	7.1	6.5	6.7	6.9	7.1	6.5	6.7	6.9	7.1
F. ..	6.2	6.4	6.7	7.0	6.2	6.4	6.7	7.0	6.3	6.5	6.7	7.0	6.4	6.5	6.7	7.0
Z.F. ..	6.2	6.3	6.6	7.0	6.2	6.3	6.6	7.0	6.2	6.4	6.6	7.0	6.4	6.5	6.7	7.0
D.H.A. ..	6.2	6.5	6.7	7.0	6.4	6.5	6.8	7.1	6.4	6.6	6.8	7.1	6.5	6.7	6.9	7.1
$V.K_3$ ..	6.2	6.5	6.6	7.0	6.4	6.5	6.7	7.1	6.4	6.5	6.7	7.1	6.5	6.6	6.9	7.1
P.B. ..	6.5	6.6	6.9	7.1	6.5	6.6	6.9	7.1	6.5	6.6	6.9	7.1	6.5	6.7	6.9	7.1
$NaNO_2$ ..	6.2	6.5	6.7	7.0	6.4	6.6	6.8	7.1	6.5	6.6	6.8	7.1	6.5	6.7	6.9	7.1
B. ..	6.5	6.6	6.8	7.1	6.5	6.6	6.9	7.1	6.5	6.6	6.9	7.1	6.5	6.7	6.9	7.1
F. + D.H.A. ..	6.2	6.3	6.5	6.8	6.2	6.3	6.5	6.8	6.2	6.4	6.6	6.8	6.4	6.5	6.8	7.0
F. + $V.K_3$ ..	6.2	6.3	6.5	6.8	6.2	6.3	6.5	6.8	6.2	6.4	6.6	6.8	6.4	6.5	6.7	6.8
F. + P.B. ..	6.2	6.3	6.6	6.8	6.2	6.3	6.6	6.8	6.4	6.5	6.6	6.8	6.4	6.5	6.7	7.0
F. + $NaNO_2$ ..	6.3	6.3	6.6	6.8	6.3	6.4	6.6	6.8	6.4	6.5	6.6	6.9	6.4	6.5	6.7	7.0
D.H.A. + $V.K_3$ ..	6.3	6.3	6.6	6.8	6.3	6.4	6.6	6.8	6.4	6.4	6.6	6.9	6.4	6.5	6.7	7.0
D.H.A. + P.B ..	6.3	6.4	6.6	6.8	6.3	6.5	6.6	6.9	6.4	6.5	6.6	7.0	6.5	6.5	6.7	7.1
D.H.A. + $NaNO_2$	6.3	6.4	6.6	6.8	6.3	6.4	6.6	6.8	6.4	6.5	6.6	6.9	6.4	6.5	6.7	7.0
$V.K_3$ + $NaNO_2$ ..	6.3	6.3	6.6	6.8	6.3	6.4	6.6	6.8	6.4	6.5	6.7	7.0	6.4	6.5	6.8	7.0

Effect of preservatives on the change of pH of oyster meat at 5-10.5°C. Original pH of oyster meat 6.6

Control	0.02%					0.01%					0.002%					0.001%				
(Time day) Preservative	1	2	3	5	7	1	2	3	5	7	1	2	3	5	7	1	2	3	5	7
Control	6.5	6.2	4.8	4.5	5.2	6.5	6.2	4.8	4.5	5.2	6.5	6.2	4.8	4.5	5.2	6.5	6.2	4.8	4.5	5.2
F. ..	6.5	6.3	5.2	4.7	5.2	6.5	6.3	5.2	4.8	5.2	6.5	6.3	5.0	4.8	5.0	6.5	6.2	5.0	4.6	5.0
Z.F. ..	6.6	6.4	5.4	4.8	5.2	6.6	6.4	5.4	5.0	5.2	6.5	6.3	5.2	5.0	5.2	6.5	6.2	5.0	4.8	5.0
D.H.A. ..	6.5	6.3	5.2	4.6	5.0	5.5	6.3	5.0	4.6	5.0	6.5	6.2	4.8	4.6	5.0	6.5	6.2	4.8	4.6	5.0
V.K$_3$ ..	6.5	6.3	5.2	4.7	5.0	6.5	6.3	5.2	4.7	5.0	6.6	6.3	5.0	4.7	5.0	6.5	6.2	5.0	4.6	5.2
P.B. ..	6.5	6.2	5.0	4.6	5.2	6.5	6.2	4.8	4.6	5.2	6.5	6.2	4.8	4.5	5.2	6.5	6.2	4.8	4.5	5.2
NaNO$_2$ ..	6.5	6.3	5.0	4.7	5.2	6.5	6.3	4.8	4.6	5.2	6.5	6.2	4.8	4.5	5.2	6.5	6.2	4.8	4.5	5.2
B. ..	6.5	6.2	4.8	4.5	5.2	6.5	6.2	4.8	4.5	5.2	6.5	6.2	4.8	4.5	5.2	6.5	6.0	4.8	4.5	5.2
F. + D.H.A. ..	6.5	6.3	5.6	5.0	5.2	6.5	6.3	5.6	5.0	5.2	6.5	6.3	5.4	5.0	5.2	6.5	6.2	5.2	5.0	5.2
F. + V.K$_3$ ..	6.5	6.4	5.8	5.0	5.2	6.5	6.4	5.8	5.0	5.2	6.5	6.4	5.6	5.0	5.2	6.5	6.3	5.4	5.0	5.2
F. + P.B. ..	6.5	6.2	5.4	4.8	5.0	6.5	6.2	5.4	4.8	5.0	6.5	6.3	5.4	4.8	5.2	6.5	6.2	5.0	4.7	5.0
F. + NaNO$_2$ ..	6.5	6.3	5.6	4.8	5.0	6.5	6.3	5.4	4.8	5.2	6.5	6.2	4.8	5.0	5.2	6.5	6.2	4.	4.8	5.0
D.H.A. + V.K$_3$ ..	6.5	6.3	5.6	5.1	5.2	6.5	6.3	5.5	5.2	5.2	6.5	6.2	5.0	4.8	5.2	6.5	6.2	4.8	4.8	5.0
D.H.A. + NaNO$_2$	6.5	6.2	5.2	4.8	5.0	6.5	6.2	5.0	4.8	5.2	6.5	6.0	4.8	5.0	5.2	6.5	6.2	4.8	4.8	5.0
D.H.A. + P.B. ..	6.5	6.2	5.2	5.0	5.0	6.5	6.2	5.3	5.0	5.0	6.5	6.2	5.0	4.8	5.2	6.5	6.2	5.0	4.8	5.0
V.K$_3$ + NaNO$_2$ ..	6.5	6.2	5.4	5.0	5.0	6.5	6.2	5.2	4.8	5.2	6.5	6.0	5.0	5.0	5.2	6.5	6.2	4.8	4.8	5.0

Table VII

Effects of preservatives on round raw marine products

Material		Preservative	a	Control					F.				
		Time in Hours	b	18	24	36	52		18	24	36	52	
SARDINE ($23–31^{\circ}$C)*	OBSERVATION	Putrid Smell ...	c	±	+	+ +	+ + + +		−	−	−	+ +	
		Bad Change of Surface Colour	d	−	+	+ +	+ + +		−	−	+	+ +	
		Elasticity of Flesh ...	e	−	−	−	−		+	±	−	−	
		Turbidity of Body Extract Fluid ...	f	+	+ +	+ + +	+ + + +		+	+	+ +	+ + +	
		pH of Body Extract Fluid ...	g	6·4	6·4	6·8	7·0		6·0	6·2	6·4	6·8	
		Edibility ...	h	?	bad	bad	very bad		fit	fit	?	bad	
		Order of Preservation Effect...	i	17					10				
SHRIMP ($23–31^{\circ}$C)*		Putrid Smell ...	j	−	+	+ + +	+ + + +		−	−	+	+ + +	
		Bad Change of Surface colour	k	−	+	+ +	+ + + +		−	−	+	+ +	
		Elasticity of Flesh ...	l	+	−	−	−		+	+	−	−	
		Turbidity of Body Extract Fluid ...	m	+	+ +	+ + +	+ + +		+	+	+ +	+ + +	
		pH of Body Extract Fluid ..	n	6·0	6·5	6·8	7·2		5·8	6·3	6·5	6·8	
		Edibility ...	o	?	bad	bad	very bad		fit	fit	bad	bad	
		Order of Preservation Effect...	p	17					11				
OYSTR ($5–11^{\circ}$C)*		Time in Days ...	q	1	2	3	5	7	1	2	3	5	7
		Putrid Smell ...	r	−	−	±	+ +	+ + +	−	−	−	+	+ +
		Bad Change of Surface Colour	s	−	−	+	+ +	+ + +	−	−	−	+	+ +
		Elasticity of Flesh ...	t	+	−	−	−	−	+	+	±	−	−
		Turbidity of Body Extract Fluid ...	u	+	+ +	+ + +	+ + +	+ + +	+	+	+	+ +	+ + +
		pH of Body Extract Fluid ...	v	6·5	6·0	4·8	4·4	5·2	6·5	6·2	5·4	4·8	5·2
		Edibility ...	w	fit	fit	bad	bad	very bad	fit	fit	fit	bad	bad
		Order of Preservation Effect...	x	17					11				

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* [illegible] fresh + very slightly or hardly putrefied

a	Z.F.					D.H.A.					V.K3				
b	18	24	36	52		18	24	36	52		18	24	36	52	
c	−	−	−	+ +		−	±	+	+ + +		−	±	+	+ + +	
d	−	−	+	+ +		−	−	+	+ +		−	+	+ +	+ + +	
e	+	+	−	−		+	−	−	−		+	±	−	−	
f	+	+	+ +	+ + +		±	+	+ +	+ + +		±	+	+ +	+ + +	
g	6·0	6·2	6·4	·8		6·2	6·4	6·6	7·0		5·8	6·4	6·6	6·8	
h	fit	fit	fit	bad		fit	?	bad	bad		fit	?	bad	bad	
i	9					13					11				
j	−	−	±	+ +		−	+	+ +	+ + +		−	−	+	+ + +	
k	−	−	+	+ +		−	−	+ +	+ +		−	+	+ +	+ + +	
l	+	+	−	−		+	−	−	−		+	±	−	−	
m	+	+	+ +	+ + +		+	+ +	+ +	+ + +		+	+	+ +	+ + +	
n	5·8	6·3	6·4	6·8		6·0	6·4	6·8	7·0		5·8	6·4	6·6	6·8	
o	fit	fit	?	bad		fit	?	bad	very bad		fit	fit	bad	very bad	
p	9					13					12				
q	1	2	3	5	7	1	2	3	5	7	1	2	3	5	7
r	−	−	−	+	+ +	−	−	−	+	+ +	−	−	?	+	+ +
s	−	−	−	+	+ +	−	−	−	+	+ +	−	−	+	+	+ +
t	+	+	+	−	−	+	+	−	−	−	+	?	−	−	−
u	+	+	+	+ +	+ + +	+	+	+ +	+ + +	+ + +	+	+	+ +	+ +	+ + +
v	6·5	6·2	5·6	4·8	5·2	6·5	6·2	4·8	4·6	5·4	6.6	6·2	4·8	5·2	5·6
w	fit	fit	fit	bad	bad	fit	fit	bad	bad	bad	fit	fit	?	bad	very bad
x	9					13					12				

Table VII—(*contd*).

Effects of preservatives on round raw marine products—(contd.)

Material		Preservative	a	P.B.					$NaNo_2$				
		Time in Hours	b	18	24	36	52		18	24	36	52	
SARDINE (23–31 °C)*	OBSERVATIONS	Putrid Smell ...	c	−	+	+ +	+ + +		−	+	+ +	+ + +	
		Bad Change of Surface Colour...	d	−	+	+ +	+ + +		−	−	+	+ + +	
		Elasticity of Flesh ...	e	−	−	−	−		±	−	−	−	
		Turbidity or Body Extract Fluid ...	f	+	+ +	+ + +	+ + + +		±	+	+ + +	+ + + +	
		pH of Body Extract Fluid ...	g	6·0	6·4	6·8	7·0		6·0	6·4	6·6	6·8	
		Edibility ...	h	fit	bad	bad	very bad		fit	?	bad	very bad	
		Order of Preservation Effect ...	i	14					12				
SHRIMP (23–31 °C)*		Putrid Smell ...	j	±	+	+ +	+ + + +		−	±	+ +	+ + +	
		Bad Change of Surface Colour...	k	−	+	+ + +	+ + +		−	+	+ + +	+ + +	
		Elasticity of Flesh ..	l	+	−	−	−		+	−	−	−	
		Turbidity of Body Extract Fluid ...	m	+	+ +	+ + +	+ + + +		+	+ +	+ +	+ + +	
		pH of Body Extract Fluid	n	6·5	6·6	7·0	7·2		6.2	6·4	6·7	7·0	
		Edibility ...	o	bad	bad	very bad	very bad		fit	?	bad	very bad	
		Order of Preservation Effect ...	p	16					14				
OYSTER (5–11 °C)*		Time in Days ...	q	1	2	3	5	7	1	2	3	5	7
		Putrid Smell ...	r	−	−	+	+ +	+ + +	−	+	+ +	+ +	+ + +
		Bad Change of Surface Colour.	s	−	−	+ +	+ +	+ +	−	±	+	+ +	+ +
		Elasticity of Flesh ...	t	+	−	−	−	−	+	−	−	−	−
		Turbidity of Body Extract Fluid ...	u	+	+	+ +	+ +	+ + +	+	+	+ +	+ +	+ + +
		pH of Body Extract Fluid ...	v	6·6	6·0	4·6	5·0	5·4	6·6	6·0	4·8	5 0	5·2
		Edibility ...	w	fit	fit	bad	very bad	very bad	fit	fit	bad	very bad	very bad
		Order of Preservation Effect ...	x	15					14				

* Temperature of observation. — . . . fresh, ± . . . very slightly or hardly putrefied,

a	B.					F.+D.H.A.					F.+V.K3				
b	18	24	36	52		18	24	36	52		18	24	36	52	
c	+	+	+ +	+ + +		−	−	−	+ +		−	−	−	+ +	
d	−	+	+ +	+ + +		−	−	+	+ +		−	−	+	+ +	
e	−	−	−	−		+	−	−	−		+	+	−	−	
f	+	+ +	+ + +	+ + + +		+	+	+ +	+ + +		+	+	+ +	+ +	
g	6·4	6·5	6·7	7·0		5·8	6·2	6·4	6·8		5·8	6·0	6·4	6·8	
h	?	bad	very bad	very bad		fit	fit	fit	bad		fit	fit	fit	bad	
i	16					2					1				
j	+	+ +	+ + +	+ + + +		−	−	±	+ +		−	−	±	+ +	
k	+	+ +	+ + +	+ + + +		−	−	+	+ +		−	−	±	+ +	
l	+	−	−	−		+	+	+	−		+	+	+	−	
m	+	+ +	+ + +	+ + + +		+	+ +	+ +	+ + +		+	+	+ +	+ +	
n	6·5	6·7	7·0	7·2		6·0	6·2	6·5	6·8		6·0	6·2	6·4	6·8	
o	bad	bad	very bad	very bad		fit	fit	?	bad		fit	fit	fit	bad	
p	17					2					1				
q	1	2	3	5	7	1	2	3	5	7	1	2	3	5	7
r	−	+	+ +	+ +	+ + +	−	−	−	+	+ +	−	−	−	+	+ +
s	−	+	+	+ +	+ +	−	−	+	+	+ +	−	−	−	+	+ +
t	−	−	−	−	−	+	+	+	−	−	+	+	+	−	−
u	+	+ +	+ +	+ + +	+ + +	+	+	+	+ +	+ +	+	+	+	+ +	+ +
v	6·6	6·0	4·6	4·8	5·2	6·6	6·4	5·6	4·8	5·4	6·6*	· 4	5·8	4·8	5·4
w	fit	?	very bad	very bad	very bad	fit	fit	fit	bad	bad	fit	fit	fit	?	bad
x	17					2					1				

Table VII—(*contd.*).

Effects of Preservatives on round raw marine products—(contd.).

Material		Preservative	a	F + Na. NO_2					F. + P.B.				
		Time in Hours	b	18	24	36	52		18	24	36	52	
SARDINE (23-31 °C)*	OBSERVATIONS	Putrid Smell ...	c	−	−	+	+ + +		−	−	+	+ +	
		Bad Change of Surface Colour	d	−	−	+	+ + +		−	−	+	+ +	
		Elasticity of Flesh ...	e	+	+	−	−		+	−	−	−	
		Turbidity of Body Extract Fluid ...	f	+	+ +	+ +	+ + +		+	+	+ +	+ + +	
		pH of Body Extract Fluid ...	g	5·8	6·0	6·5	6·8		5·8	6·0	6·4	6·8	
		Edibility ...	h	fit	fit	?	bad		fit	fit	fit	bad	
		Order of Preservation Effect...	i	6					4				
SHRIMP (23-31 °C)*		Putrid Smell ...	j	−	−	−	+ +		−	−	+	+ +	
		Bad Change of Surface Colour	k	−	−	+	+ +		−	−	+	+ +	
		Elasticity of Flesh ...	l	+	+	−	−		+	+	−	−	
		Turbidity of Body Extract Fluid ...	m	+	+	+ +	+ + +		+	+	+ +	+ +	
		pH of Body Extract Fluid ...	n	6·0	6·2	6·5	7·0		6·0	6·2	6·5	6·8	
		Edibility ...	o	fit	fit	fit	bad		fit	fit	?	bad	
		Order of Preservation Effect...	p	5					3				
OYSTER (5-11 °C)*		Time in Days ...	q	1	2	3	5	7	1	2	3	5	7
		Putrid Smell ...	r	−	−	−	+	+ +	−	−	−	+	+ +
		Bad Change of Surface Colour	s	−	−	−	−	+ +	−	−	+	+ +	+ +
		Elasticity of Flesh ...	t	+	+	+	−	−	+	+	+	−	−
		Turbidity of Body Extract Fluid ...	u	+	+	+	+ +	+ +	+	+	+ +	+ +	+ +
		pH of Body Extract Fluid ...	v	6·6	6·4	5·4	4·8	5·0	6·6	6·2	5·4	4·6	5·6
		Edibility ...	w	fit	fit	fit	bad	bad	fit	fit	fit	bad	bad
		Order of Preservation Effect...	x	5					3				

* Temperature of observation.

− . . . fresh, + . . . very slightly or hardly putrefied,
+ . . . slightly putrefied, + + . . . moderately putrefied,

a	D.H.A. + V.K$_3$					D.H.A. + P.B.					D.H.A. + Na NO$_2$				
b	18	24	36	52		18	24	36	52		18	24	36	52	
c	−	−	−	+ +		−	−	+	+ + +		−	−	+	+ + +	
d	−	−	+	+ +		−	−	+	+ + +		−	−	+	+ +	
e	+	−	−	−		+	−	−	−		+	−	−	−	
f	+	+	+ +	+ + +		+	+ +	+ + +	+ + +		+	+ +	+ +	+ + +	
g	5·8	6·0	6·4	6·8		5·8	6·0	6·5	7·0		5·8	6·2	6·4	6·8	
h	fit	fit	fit	bad		fit	fit	?	bad		fit	fit	fit	bad	
i	3					8					7				
j	−	−	+	+ +		−	−	+	+ + +		−	−	−	+ +	
k	−	−	+	+ +		−	−	+ +	+ + +		−	−	+	+ +	
l	+	+	−	−		+	+	−	−		+	+	−	−	
m	+	+	+ +	+ +		+	+	+ +	+ + +		+	+	+ +	+ + +	
n	6·0	6·2	6·5	6·8		6·0	6·2	6·6	7·0		6·0	6·2	6·5	7·0	
o	fit	fit	bad	bad		fit	fit	bad	bad		fit	fit	?	bad	
p	4					8					7				
q	1	2	3	5	7	1	2	3	5	7	1	2	3	5	7
r	−	−	−	+	+ +	−	−	−	+	+ +	−	−	?		+ +
s	−	−	+	+ +	+ +	−	−	+	+	+	−	−	+	+ +	+ +
t	+	+	+	−	−	+	+	−	−	−	+	+	−	−	−
u	+	+	+ +	+ +	+ + +	+	+	+	+ +	+ +	+	+	+ +	+ +	+ +
v	6·6	6·4	5·4	4·6	5·4	6·6	6·2	5·4	4·8	5·2	6·6	6·2	5·2	4·8	5·2
w	fit	fit	fit	bad	bad	fit	fit	?	bad	bad	fit	fit	fit	bad	bad
x	4					8					7				

Table VII—(*contd.*)

Effects of Preservatives on Round Raw Marine Products—(contd.)

Material		Preservative	a	V.K$_3$ + NaNO$_2$					P.B + NaNO$_2$				
		Time in Hours	b	18	24	36	52		18	24	36	52	
SARDINE (23-31°C)*	OBSERVATION	Putrid Smell ...	c	−	−	+	+ + +		−	−	+	+ + +	
		Bad Change of Surface Colour	d	−	−	+	+		−	−	+	+ +	
		Elasticity of Flesh ...	e	+	+	−	−		+	+	−	−	
		Turbidity of Body Extract Fluid ...	f	+	+	+ +	+ + +		+	+ +	+ +	+ + +	
		pH of Body Extract Fluid ...	g	5·8	6·2	6·4	6·8		5·8	6·0	6·5	7·0	
		Edibility ...	h	fit	fit	fit	bad		fit	fit	bad	very bad	
		Order of Preservation Effect ..	i	5					9				
SHRIMP (23-31°C)*		Putrid Smell ...	j	−	−	−	+ +		−	−	+	+ +	
		Bad Change of Surface Colour	k	−	−	+	+ +		−	−	+	+ + +	
		Elasticity of Flesh ...	l	+	+	−	−		+	+	−	−	
		Turbidity of Body Extract Fluid ...	m	+	+	+ +	+ + +		+	+	+ +	+ +	
		pH of Body Extract Fluid ...	n	6·0	6·2	6·5	6·8		6·0	6·2	6·5	7·0	
		Edibility ...	o	fit	fit	?	bad		fit	fit	?	bad	
		Order of Preservation Effect...	p	6					10				
OYSTER (5-11°C)*		Time in Days ...	q	1	2	3	5	7	1	2	3	5	7
		Putrid Smell ...	r	−	−	−	+	+ +	−	−	−	+	+ +
		Bad Change of Surface Colour	s	−	−	+	+	+ +	−	−	−	+	+ +
		Elasticity of Flesh ...	t	+	+	+	−	−	+	+	−	−	−
		Turbidity of Body Extract Fluid ...	u	+	+	+	+ +	+ +	+	+	+ +	+ +	+ +
		pH of Body Extract Fluid ...	v	6·6	6·2	5·0	4·8	5·2	6·6	6·2	5·2	4·8	5·0
		Edibility ...	w	fit	fit	fit	bad	bad	fit	fit	fit	?	bad
		Order of Preservation Effect...	x	6					10				

* Temperature of observation. − ... fresh. + ... very slightly or hardly putrefied.

27

SIGNIFICANCE OF FISH CULTURE AS AN INTEGRAL PART OF RURAL ECONOMY IN INDONESIA

by

M. Ahjar* and R. Tasripin**

a is an agrarian country. For about he people agriculture and aquiculture e means of subsistence. Fish culture portant, and it has been practised for a time. As early as the 13th century, enacted to protect fish culture in ponds eft. In those days, fish culture was n mostly by kings and other eminent ostly for enjoyment. The construction water ponds commenced in the 15th the environments of Gresik (East Java). ntury ago (1860), the Government began ge fish culture among the people, beginst Java, where there were many suitable e religious leaders played a big part in fish culture, because of their role in the of the water supply, and this situation the end of the 19th century.

ension of fish culture has proceeded t only in the isle of Java but also in the ds, in brackishwater ponds, freshwater e fields and tanks. The area under at present is as follows:

water ponds	.. about	128,000 ha.
er ponds	..	20,000 ,,
ure in rice fields	..	65,000 ,,

only a small part of the total area used tion of other agricultural products, but is nevertheless of great importance as l part of rural economy. About 15 ple or 20% of the population are engaged uction of fish, if not as their main means ce, as an important side line.

nt, about 227 million kilograms of fish 2,270,000,000 (about $200,000,000) and 0,000,000 fry worth Rp. 400,000,000 ,000,000) are being produced.

ample of the active programme of fish he rural economy in Indonesia, the condi- Regency of Tjiandjur, West Java, is elow:

gency of Tjiandjur is situated in the he province of West Java. The area is mountainous in the north and south, whereas the middle part from east to west and along the sea in the south is flat. There are no big rivers, but only some small ones, mostly flowing to the south coast. The climate is rather hot, but somewhat milder in the north. The average rainfall is high (more than 2,000 mm. yearly) and the lateritic soil is fertile. These circumstances have made Tjiandjur famous for its rice production and its fish culture.

The regency is rather densely populated. The number of inhabitants is about 700,000 of which 90% get their livelihood from agriculture, including fish culture.

The utilization of the land is as follows:

Agriculture (wet and dry)	..	136,000 ha.
Forestry	.. ..	44,000 ha.
Fish ponds	.. ..	85 ha.
Estates	.. ..	18,000 ha.

The regency of Tjiandjur is one of the areas where fish culture was introduced very early. It is conducted not only in ponds but also in rice fields. This fish culture can be divided as follows:

Fish culture in ponds

Rearing consumption fish	Producing fry
40 ha.	45 ha.

Fish culture in rice fields

Rearing consumption fish	Producing fry (fingerlings)
6,555 ha.	3,045 ha.

Fish culture is conducted in districts with adequate water supply of which Tjiandjur, Tjirandjang, Patjet and Sukanegara, are the most important. While fish culture is only a secondary occupation for many, there are some fish farmers who have fish culture as their only means of subsistence. This group consists mostly of pond owners, who rear marketable fish or produce fry. The estimated number of farmers practising fish culture is about 300,000 while the number of full-time fish farmers is about 2,000 including families.

Inland Fisheries Service, West Java Province, Indonesia.

, Inland Fisheries Service, Tjiandjur Regency, Indonesia.

The average annual yield from fish culture in the regency of Tjiandjur is as follows:

Consumption fish			*Fry*		
Ponds	Rice fields	Total	Ponds	Rice fields*	Total
30,000 kg.	1,950,000 kg.	1,980,000 kg.	225,000,000 kg.	—	225,000,000

The approximate value is as follows:

(*a*) consumption fish at Rp. 8.- per kilo	Rp.	15,84
(*b*) fry at Rp. 2.50 per thousand	,,	56
Total	Rp.	16,40

Some figures concerning the income of farmers (having fish culture as a side income) are given

1. Farmer fish culture in own rice field

Expenditure (per hectare per year):

(*a*) Cost of preparing the field purchase of seeds, transplanting, manuring, weeding of the first rice cultivation (5 months)	Rp.
(*b*) Cost of the second rice cultivation with more manuring	,,
(*c*) Cost of the 'panjelang' fish culture (rearing fingerlings 3 times in the interval between first and second rice cultivation) 3 x Rp. 200.-	,,
(*d*) Cost of fish culture between the rice plants (rearing of fry, twice)	,,
Total	Rp.

Income

(*a*) first rice crop, 2.8 tons	Rp.
(*b*) second rice crop, 1.5 tons	,,
(*c*) panjelang fish culture 225 kg. at Rp. 8—per kg.	,,
(*d*) fish culture between the rice plant 28 kg. fingerlings at Rp. 25.- per kg.	,,
Total income	Rp.

Thus, the profit from the combined operation is Rp. 2,700 per hectare, as against only Rp. 1,100 if rice is cultivated alone.

2. Fish culture in rented rice field

In case the rice field is rented, the yearly rent of Rp. 2,000 per hectare has to be added to the figures, so that the profit will be only Rp. 7 in this case the farmer follows another system does not cultivate a second rice crop, but chang with fish as second crop ('palawidja') du months with the 'panjelang' culture. The ex ture and income will be as follows (per he e

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* The rice fields are used only for nursing the fry produced in ponds.

first rice cultivation		Rp. 1,500.-
fish culture between the rice		,, 300.-
fish as second crop (duration 1 month):		
—purchase of fry, six times at Rp. 200	Rp. 1,200	
—straw cutting, every 3 months, i.e. twice (at Rp. 150.)	,, 300	
—raising dikes	,, 300	
—repairs	,, 50	
		,, 1,850.-
t of field		,, 2,000.-
Total expenditure		Rp. 5,650.-

n rice cultivation	Rp. 2,800.-
culture between the rice	,, 700.-
culture as palawidja, Rp. 600 x 6	,, 3,600.-
Total income	Rp. 7,100.-

ase the profit is Rp. 1,450.

ar that in the area of Tjiandjur where many farmers still work on rice fields rented owners, the latter system is preferable. This is also the reason why the introduction d rice crop does not receive much attention.

ome of full-time fish farmers is as follows:

ing marketable fish (common carp):

ation of rearing: 3 months. In one year 3 crops (rest of time needed for preparation).

e

ng material 20 kg. fingerlings	Rp. 160.-
ood 100 kg. rice bran and some manure	,, 100.-
ation and repairs	,, 100.-
Total expenditure per crop (three per year)	Rp. 360.-
Total expenditure per year	Rp. 1,080.-

. fish per crop—720 kg. per year, at Rp. 8.- per kg.	Rp. 5,760.-
	,, 4,680.-

uction of fry (common carp): Breeding takes place 10 times a year.

(per hectare)

iring the hatchery, once in 3 months, i.e. 4 times a year, at Rp. 100.-	Rp. 400.-
ing of the breeders for 360 kg. crop, 5.5 tons rice bran	,, 1,375.-
irs to equipment and purchase of new materials..	,, 275.-
orkers, 10 persons for every breeding (carriers of fry), 10 times a year, at Rp. 7.50 per son	,, 750.-
Total expenditure	Rp. 2,800.-

hectare)

from each breeding:

,000 fry (500,000 × 10) at Rp. 2.50 per 1,000	Rp.12,500.-
:	,, 9,700.-

The profits will be higher if a greater part of the work is performed by the farmer himself.

The figures stated above show that with fish culture there is always some surplus which can be used for improving the living conditions of the farmers. Therefore not only in the regency of Tjiandjur but also in other areas, fish farmers, whole time as well as part time, have better living conditions than farmers who do not cultivate fish. Well-built houses and a pilgrimage to Mecca can often be had with the surplus of agricultural and fishery income. Fish farmers do not have to worry about fish for the family on important feast days. They seldom fail in their duties to the Government such as payment of land revenue or income taxes. Last but not the least, the fish farmers always have suffi animal protein in their daily diet.

In areas like the regency of Tjiandjur r attention is paid to fish culture and where there sufficient supply of water and fish fry, every fa likes to practise some fish culture. In compa with the cultivation of other products, there i much risk in cultivating fish. Prevention of of water, manuring the pond or rice field and app the proper stocking rate are the main prob which are relatively easy. Pests, such as t snakes, frogs and crabs can easily be minimize regular control measures. Diseases occur infrequently.

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THE INLAND FISHERIES EXTENSION SERVICES IN INDONESIA

by

M. Ahjar*

In Indonesia a well-operating extension system is already organized and spread over the whole country. This system includes a head office in Djakarta, a Provincial office in every Province and regional offices in Regencies and Districts with extension personnel down to the villages. All the personnel are not only experts in matters concerning every part of the inland fishery, but they must also be sympathetic and have the confidence of the people.

The task of the extension worker is not an easy one, because his success depends partly on the people themselves. The Indonesian farmers in general, fishermen and fish farmers not excluded, have not achieved the needed development yet. Many of them have never even visited an elementary school, although the Indonesian Government is still doing much to combat illiteracy. Many new matters have come from the scientific laboratories and all these cannot be automatically taken over by the fish farmers; even if they are able to read and write, results of research must be clearly explained to them.

The task of an extension officer becomes even more difficult because he is expected to deal with the activities of other services such as agriculture, animal husbandry, public health, irrigation etc. The fishery extension officer must therefore co-operate with everyone in his area.

Summarizing, the fishery extension officers be :

(*a*) Real fisheries experts (differing in d for high, middle and low grade offi
(*b*) Persons able to co-operate with officers other services.
(*c*) Responsible. Though the farmers very simple folk, their confidence be lost if the information given th not reliable.
(*d*) Persevering. Innovations cannot introduced overnight. The exte officer often obtains success only many trials.
(*e*) Familiar with human nature so tha may be able to use the right syste extension, according to the idiosync of the farmers concerned.
(*f*) Be a popular speaker. During the exte work the fishery officer often ha make an appeal in talks and demon tion. A sense of humor is an
(*g*) Be a jack-of-all-trades. He may ha deal with matters of interest to farmers over and above fis techniques.

Subjects for extension work.—There are items which have to be made known to the fishe ırmers. Thus in inland fisheries, they will lture in several types of impounded waters shwater ponds, freshwater ponds and rice- well as fisheries in lakes, rivers and swamps. : information should be imparted in such a t it is comprehensible to the simple fish or fishermen. Interest must also be in new methods.

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* Chief, Inland Fisheries Service, West Java Province, Bandung, Indonesia.

ns of carrying scientific knowledge shermen and fish farmers.

lucation : At present there are two inland schools in Indonesia for training junior personnel in extension work. For fisher- fish farmers, free fishery courses have been n many villages, the duration of which is ix months. Lessons of two or three hours twice a week.

ourse is conducted in a school building l from the education service, in the village house borrowed from the head of the village, ne similar place. The role of the head of e is very important. When he also attends e, other people follow him in large numbers, continued attendance, the number of the nts and the success of the course depends n the teacher himself.

ırmers who can read and write note down g they have learned; others who are merely memorise, or take along a small boy tary'.

tical lessons alone are not sufficient. They supplemented by object lessons, using a a rice-field of one of the participating Once or twice during the course, s are made to a well-developed fishery l the costs of the village course are paid by ernment. At the end of the course the eceive a diploma.

ance at a course is not compulsory. The of such fishery courses for West Java is s:

Number of courses	Number of Participants
53	1,634
124	4,207
108	2,307

the regular fishery courses, so-called on Talks' are occasionally held, when the ficer arranges a small gathering in a fish nouse.

etings : Improvements in fisheries are by means of meetings: general meetings ople in the villages, meetings of heads of meetings of fishery co-operative societies s. The fisheries officer plays an important ese meetings.

c. *Visits :* The fishery officer regularly visits the farmers in their own homes. Generally farmers are chosen who have some influence in the village. These are called 'contact persons'. Improved methods applied by these persons, who are unpaid, will be followed by others in the village. Their activity is based on friendship with the fishery officer and on their own profitable operations, for which they can always get free advice from the fishery officer.

d. *Demonstration fields :* Everything that is proposed to the farmer is, if possible, confirmed by demonstration. Most of the farmers are convinced when they have seen with their own eyes the results of the newly proposed measures. Although there are some permanent Government demonstration centres (Governmental hatcheries), in some cases the demonstration project is of a temporary nature.

e. *Excursions :* Excursions to more developed fishery areas are organized, so that farmers may see actual achievements with the new methods suggested by the fishery officer. These excursions may be paid for jointly by the farmers and the Fishery Service.

f. *Exhibitions:* These are held in fairs and at large gatherings and popular interest is maintained by means of shows and entertainment.

g. *Brochures:* Simple illustrated brochures are distributed among the fish farmers.

The activities mentioned above are sometimes carried out in co-operation with other services.

The cost of this system of extension is not very high. In the province of West Java for instance, the annual budget for the Fishery Extension Service including salary, writing material, transport, (telephone etc.) is as follows:

Year	Budget	Fish production
1952	Rp. 2,650,000	16,000,000 kg.
1953	,, 2,750,000	26,000,000 kg.
1954	,, 4,430,000	33,000,000 kg.

(The average price of fish is Rp. 8 per kg.)

Items of Improvement Effected.—The main aims and achievements of the Fisheries Extension Service in Indonesia are:

a. Production of more fish fry
b. Better quality of breeders, spawners and fry
c. Better feeding and manuring
d. Proper density of stocking
e. Better storage and transporting methods
f. Preservation methods
g. Water regulations
h. Better equipment
i. Co-operative societies
j. Fish conservation in lakes, swamps and rivers
k. Eradication of pests, diseases etc.

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CO-OPERATIVE MARKETING ORGANIZATION IN INDONESIA WITH REFERENCE TO THE ERETAN CO-OPERATIVE FISH AUCTIC SYSTEM IN WEST JAVA

by

Eddiwan*

The Indonesian Archipelago lies astride the Equator and consists of more than 3,600 islands of which some of the larger ones such as Java, Sumatra, Kalimantan (Borneo), Sulawesi (Celebes) and Nusa Tenggara (Lesser Sunda Isles) form the most important and well-populated areas.

The Archipelago is surrounded by several waters among which the chief are:

1. The Indian Ocean, in the West and South-West.
2. The Arafura Sea, in the South-East.
3. The Pacific Ocean in the East.
4. The South China Sea in the North.

A number of minor seas, straits, gulfs and bays are interspersed with the numerous islands in this widespread area and the fisheries of all these waters are of great economic importance to Indonesia. The Strait of Malacca, between Sumatra and the Peninsula of Malaya, the Java Sea, S.E. of Sumatra, South of Borneo and Java, the Strait of Macassar, between the islands of Borneo and Celebes and the Banda Sea, in the Moluccas are some of these.

The seas, straits and other waters occupying some 75 per cent of the total territory of the Republic of Indonesia have an area of more than five million sq. km., while the coast-line of all the islands together is longer than the circumference of the globe.

According to research on taxation and other data, the basic fish production in the Indonesian waters can be estimated to be at least four million tons per year, based upon 0.8 ton per sq. km. per year. It is noticeable, however, that some fishing areas such as the Bawean islands group and the Muara Rokan near Bagan Siapi-api in East Sumatra range in production from 2 to 50 tons per sq. km. per year.

The island of Java is the most densely populated island with more than 50 million inhabitants, making up 75 per cent of the total population of the Republic of Indonesia. This means that this island occupies a major place in the consumption of fish. Unfortunately the fish yield around the island is far from enough to supply its animal protein requirements.

The figures given below show the appro fish landings in 1953, by fishing areas:

	Area	Production metric tons	Val Rup
1.	Java	71,214	168,24
2.	Sumatra	131,388	752,57
3.	Borneo	75,000	251,25
4.	Celebes, the Moluccas and the Lesser Sunda Island ..	97,500	369,35

The figures show total fish landings of 3 tons valued at Rp. 1,541,425,000. This do include large quantities which are landed i controlled areas, or those parts of the catches by the fishermen themselves.

Considering that the landings amount only per cent of the estimated basic production of t Indonesian waters, it will be clear that the still a great possibility to increase the catche

The main areas of fish production

As far as the production of sea fish is conc the Indonesian Archipelago can be divided seven areas:

1. The area along the North coast of where the 'mayang fisheries' yield not less 90 per cent of the landings. The most imp commercial species caught in this fishery 'layang' fish (*Decapterus russelli*).

2. The N.E. coast of Sumatra, espe in the Bagan Siapi-api area surrounding the of the Rokan river, with its 'djermal fishe a kind of wooden fish trap. This kind of fi depends on the strong current and the differences between high and low tide.

3. The northern part of Celebes, Min and the island groups of the Moluccas alon border of the Pacific Ocean well known tuna area.

4. The West and South coast of Borneo k as the area of the 'sero', a bamboo fish trap which the 'kembung' species (*Scomber kanag* is mainly caught.

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* Chairman of the Federation of the Indonesian Fishermen Co-operative Societies, Pasar Ikan, Djakarta Indone

[1] US $1 = Rp. 11.40.

he Macassar Strait, where the ‘ torani ’ (flying fish, *Cypsilurus*) are exploited mboo floating traps.

he Bali Strait and Southwards, where onesian ‘ sardine ’, known as the ‘ lemuru ’ *leiogaster*) appears annually during its nd amounts to 3,000 tons. The catch is l during dark nights with the aid of a m torch to attract the fish.

he Thousand Islands in the Bay of a and the waters in the surroundings of and Billiton are known as the area of ro ami ’, a Japanese method of reef fishery. incipal catch consists of ‘ ekor kuning ’ (yellow tail, *Caesio erythrogaster*).

e seven main areas, 300,000 operatives, cent of the total Indonesian fishermen are in fisheries mostly using sailing vessels and primitive-gear, although it is noteworthy that 747 motor vessels and more than 93,385 sailing vessels operated in 1953.

Marketing Organizations

Marketing organizations run by fishermen's co-operatives or by local authorities are well developed in Java.

At the same level of development can be listed the following marketing organizations on other islands :

1. Teluk Betong, Kotta Agung, Labuhan Meringgai (in Sumatra).
2. Pontianak, Singkawang, Sungai Pinjuh (in Borneo).
3. Macassar, Menado, Air Tembaga (in Celebes).

Up to the present there are 159 fish auction units and 246 fishermen's organizations as shown below :

List I

Fish-Auction units (1954)

Regions	set up by				
	Fishery Co-operatives	Institutes	Local Authorities	Other Organizations	Total fish Auction units
.. .. ..	28	—	17	—	45
a	63	—	—	—	63
.. .. ..	15	—	—	—	15
.. .. ..	2	—	—	—	2
Total Java/Madura ..	108	—	17	—	125
atra	1	—	—	3	4
tra	—	—	—	—	—
ra	—	—	—	—	—
atra	—	—	—	—	—
Total Sumatra ..	1	—	—	3	4
eo	—	5	—	—	5
Borneo	—	—	—	—	—
Total Borneo ..	—	5	—	—	5
bes	—	—	6	3	9
bes	—	—	12	1	13
Total Celebes ..	—	—	18	4	22
ıccas	—	—	1	2	3
ıccas	—	—	—	—	—
Total Moluccas ..	—	—	1	2	3
da Is.	—	—	—	—	—
Total fish-auctions in Indonesia ..	109	5	36	9	159

List II

Fishery Organizations in 1954

	Fishery Co-operatives	Institutes	Other Organizations	Tot
West Java	26	1	4	31
Central Java	15	—	—	15
East Java	9	1	4	14
Madura	8	—	—	8
Total Java/Madura	58	2	8	68
South Sumatra	21	—	2	23
West Sumatra	31	—	1	32
East Sumatra	31	—	1	32
North Sumatra/Atjeh	7	—	—	[illegible]
Total Sumatra	90	—	4	94
West Borneo	8	1	—	[illegible]
South East Borneo	9	3	—	12
Total Borneo	17	4	—	21
South Celebes	6	—	—	6
North Celebes	14	—	2	16
Total Celebes	20	—	2	22
South Moluccas	9	—	—	9
North Moluccas	10	—	1	11
Total Moluccas	19	—	1	20
Lesser Sunda Is.	21	—	—	21
Total Fishery Organizations in Indonesia	225	6	15	246

The above figures show that fish auction units are not always established in every main fishing area. This is because some of these areas have a small population with a low purchasing power, or a thinly populated hinterland. In both cases the establishment of fish markets is of little value. In these cases the fish is usually preserved at the local landing places to be subsequently transported to other areas, especially to Java with its more than 50 million inhabitants.

Preserved fish and other fish products are not sold at auction-centres but directly offered by the producers to wholesale dealers. In this branch of fish trading an organized market system is not found important.

The establishment of marketing organizations

A regular marketing scheme was carried out as early as 1912, when the first organized fish auction unit was set up in Tegal in Central Java.

Whereas at first nearly all the fish auction completely run and controlled by local govern or by the Institute of Sea Fisheries, after War II this was gradually transferred to fisher co-operative organizations, except for a few units which because of local circumstances remained in the hands of governmental b

Privately organized fish auctions are pro in Indonesia. In this connection, the inten the Indonesian Government may be noted, i.e

1. to intensify the production of fish in to meet successfully the nation's needs for pr

2. to improve the fishermen's standard of for instance,

(*a*) The fishermen are able to obtain cred their industries either in the for cash or materials, equipment, vessels,
(*b*) Fishery materials are effectively distrib
(*c*) Fishermen can easily be contacted connection with the introduction of

methods of fishing for improvement of the current systems and so on.

Savings of the fishermen are properly administered.

Funds are made available for sea and life accident assurance and for social improvements, e.g. water-supply for fishermen's villages, literacy, health and housing problems and so on.

2 the Ministry of Agriculture supported by
istry of Internal Affairs, issued a circular
all local authorities throughout Indonesia,
the following :

Fish auctions must be transferred to local
nen's co-operative organizations in the areas
ned.

Taxes and other commissions derived from
auctions should not be considered as
ies, but as contributions of the fishermen as
ers of the organization.

In areas without any fishermen's organiza-
ish auctions are to be managed by the local
ment.

Commission

uction commissions are applied entirely for
fit of would be fishermen. According to
get of fishery co-operatives, the usual ap-
on is as follows :

% for salaries
% ,, capital increment
% ,, administration expenses
% ,, insurance (sea accidents, etc.)
% ,, social funds

%

-operative Fish auction of Eretan in Java

ethod of operating fish auction in Indo-
her by a fishery co-operative or by any
dy, is in principle the same, with only
ferences depending on local circumstances.

der to get some idea of this business
on of Eretan is described as an example.
is a specific Indonesian fishery village
n the north coast of west Java, about 100
m Djakarta. The village has a popula-
,838 souls including 4,542 fishermen, who
out 800 houses. The fishing fleet consists
iling (not motorized) vessels about 10.5m.
n. The following figures will show the annual catch sold at the auctions in the years 1950-1954 :

Year	Catch kg.	Value Rupiahs
1950	1,822,649	2,380,175.59
1951	2,341,040	3,980,634.15
1952	2,031,594	3,296,041.14
1953	2,194,434	4,520,608.10
1954	2,477,946	4,879,794.71

Hence, an average of about six tons of fresh fish daily valued at about Rp. 12,000 is sold in this market.

The market is located at the mouth of the Eretan River. The east bank of the river which is reinforced, forms a very suitable landing and anchoring place. There are a salt godown and a general godown attached to the auction building. There is also room for drying of gear and fish. Though the building is not very big, it is the largest one in the village. Nearly half is occupied by the auction premises, which are divided into two platforms for the sale of fish closed off by a low, wooden fence. The fish is laid in heaps or put into bamboo baskets on the platform.

When the vessels return after fishing and stop alongside, the fish are sorted and put into bamboo containers with a capacity of 10 to 15 kg. and then carried to the auction place by the fishermen. Each basket is weighed and the weigher issues a voucher on which the nett weight of the fish is noted. As soon as there are enough fish to be sold, an iron bar is beaten as a sign to start the auction and the fish is sold to the highest bidder. The fish buyers, who during the auction remain outside the auction platform, are now allowed to enter to carry off their purchase. The fishermen themselves stay outside the auction place until their fish is sold after which they obtain their money according to the procedure described below. The auction takes place continuously, but alternates from platform to platform.

The auction team consists of the following persons:

1. Cash register operator, 2. Cashier, 3. Auctioneer and/or crier, 4. Auction book-keeper, 5. Ticket writer, 6. Statistics clerk, 7. Weigher, 8. Mandoors and coolies.

During the auction, the auctioneer and the ticket writer are on the auction platform, whilst the cash-register operator is seated behind with the cashier sitting beside him. The auctioneer moves across the auction platform to and fro between the rows of heaps and baskets of fish. He carries a stick with which he indicates the fish to be sold and invites bids. The fish may be sold in single or multiple heaps on baskets. He calls out the weight, species of the fish and its owner's name. At the close of the bidding, he shouts the name of the successful buyer and the price obtained and the ticket writer notes it down on a slip, half of which he hands over to the fisherman and the other one to the fish buyer. The statistics clerk records the data in the control book. Payment is made in cash and the owner can receive his money from the cashier by handing over the slip, after deduction of charges such as auction commission, loans, savings and so on.

Besides the regular auction teams there are office personnel, consisting of an auction manager, usually the Administrator of the Co-operative himself; statistics clerks; administration personnel; and the cashier. All in all there are some 18 persons engaged in running an auction, whose total wages amount to about Rp. 80,000 annually. Receipts from the 5 per cent auction commission can be estimated to be about Rp. 250,000 per year, besides other revenues such as interest on credits, and profits in the distribution of fisheries material and equipment.

The fish auction is open to anyone wishing to buy. About 40 per cent of the fish is sold fresh to local consumers; the rest including big fish is iced and transported by trucks to the hilly regions (Bandung) and other places. Fresh fish for inland consumption in regions off the coast are retailed from the free markets and further distributed by fish hawkers.

The success of a co-operative managed fish farm depends on the following essential factors:

1. The efficiency of the co-operative organization.

2. The earnestness of the fishermen themselves to sell their catch via the auctions which means more time available to rest, to do other work (repairing of nets and gears) and prepare themselves for the next catch.

3. The support of the Government to help the fishermen.

The success in this line will benefit the community considerably as is clear from the following instances:

In Pemalang in Central Java the local co-operative organization decided to build and repair houses for its members. So far about 150 fishermen's houses have been built in this way and repaired free of charge, the expenses being covered by a voluntary contribution of 2 per cent on each sale at the auction. It was decided at the members' meeting of 1953 to build a pier at the mouth of the Pemalang river for the use of sailing vessels. The project was executed with charges collected from the members who paid another 2 per cent on their sales. This pier was constructed without any governmental aid except the blue-print which was drawn up by the Harbour Service at Tegal.

The fishery co-operatives of Tegal, Rem
Tawang, and Wonokerto in Central Java, hav
up clinics providing free treatment to the fishe
In view of the shortage of physicians in Indo
these clinics mean a great deal to the fi
community. In cases of emergency the pa
are taken to hospitals at the expense of
co-operatives.

Besides the fishing community itself, the
society as a whole is encouraged to emulate
co-operative activities. However, it is not so
in all cases for fishery co-operatives to fun
successfully. Lack of proper understanding an
members and sabotage from jealous money-le
who are also fish traders and who see dang
their trade in co-operative activities, are obs
frequently to be faced by co-operatives. In fact
of the great problems of the Government and
operative organizations is the liberation of
fishermen from the clutches of money-lenders.

These difficulties are in some cases easily
mountable. In some places the Government fol
another policy by creating Institutes intend
preliminary bodies which later on are to be
formed or absorbed into co-operatives.

Government role in the Development
Control of Marketing Schemes

The Government takes an active part in
development and protection of the marketing sc
by aiding and supporting every movement w
contributes to the hygienic and efficient sale of
When necessary, officers of the Sea Fish
Service give guidance and assistance in the i
stages of establishing co-operatives.

The Sea Fisheries Service has in its annual bu
a small sum for establishing marketing organizat
There are also funds reserved for six months' t
ing courses for officials and administrators. H
ever, a well-planned marketing scheme cove
all Indonesia has not yet been set up, chiefly
account of the shortage of budget.

The control of the co-operative marketing orga
tions is managed by two governmental Serv
i.e. the Sea Fisheries Service of the Ministr
Agriculture and the Co-operative Service of
Ministry of Economy. The Sea Fisheries Se
promotes and assists in matters of fisheries
nology and co-operative administration, whilst
Co-operative Service takes care of the organizatio
co-operatives. Monthly reports, statistical records
drawn up and forwarded to both Services, but
day-to-day control remains in the hands of the
Fisheries Service.

ment subsidies to marketing organization
d only in exceptional cases as in the build-
53 of the Surabaya fish-harbour with a
long pier and auction building. The Sea
Service spends an amount of Rp. 300,000
on the collection of statistics, which are
eriodically by the co-operatives. Govern-
ns are granted through the Central Co-
Organization, i.e. the Federation of the
n Fishermen's Co-operative Societies, and
ivided into three categories:

oans in the form of money, which has so
ounted to Rp. 2,500,000, though requests
to Rp. 30,000,000.

oans in the form of materials for fisheries
ent.

oans in the form of powered fishing vessels.

vessels are handed over to the fishermen, group of fishermen or co-operative organization without any payment in advance, but on the condition that repayment of the debt will be in instalments of 15 per cent of catch.

In 1953 the Federation of the Indonesian Fishermen's Co-operative Societies established a Co-operative Fisheries Bank with a capital of Rp. 200,000 in order to meet the needs and cover the shortage of credits of those co-operatives.

In conclusion, it may be said that the marketing organizations in Indonesia are playing an important role in the development of fish production and the framing of a comprehensive fisheries policy in Indonesia. There is, however, still a great need for the development of a well-organized fish marketing system for the benefit of the fisherman as well as of the consumer.

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PROGRESS OF FISHERIES STATISTICS IN JAPAN

by

T. Yamamoto*

neral history.—Statistics of fisheries
n in Japan have been supplied by the
of Agriculture and Forestry since 1894.
the methodology has been developed on
lines only in the present decade. Up to
veys were carried out once a year by the
n charge of statistics in a city, town or
The results were summed up by the pre-
overnments and reported to the Ministry
ture and Forestry. As fisheries are usually
hroughout the year, obviously it is very
get anything like accurate statistics by
annual survey. Because few fisheries
were engaged in this survey, the results
emely erroneous and inaccurate. In
survey items were only related to the
y kinds of fish or product. The quantity
of fishery, number of fishing units and
ort were not enumerated except in such
s large trawlers, whaling etc. Fisheries
cluding such items as the fishermen, their
s, fishing boats etc. had never been
before World War II.

s surveys used to be only one of the activities of the statistics section of the Ministry of Agriculture and Forestry which compiled various types of agricultural statistics relating to agriculture, forestry, livestock and fisheries. As this section had no local offices or branches, actual surveys had to depend upon the reports of the city, town or village offices.

2. Establishment of statistical survey system after the War.—At the end of World War II, Japan faced a serious food scarcity owing to the loss of many territories and the increase of population due to evacuation from overseas. In order to stabilize the demand and supply of food, it was keenly felt that the Government of Japan must obtain much more reliable statistics regarding the main crops such as rice, wheat and sweet potato. Hence the Crop Reporting System was set up in February 1947 as a statistical survey organization under the Ministry of Agriculture and Forestry. This system consists of the Statistical Survey Bureau in the Ministry of Agriculture and Forestry as the central office, 49 Statistical Research Offices in the prefectures including approximately 1,000 Branch Offices, in which 13,000 officials were appointed as

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eries Statistics Section, Statistics and Survey Division, Ministry of Agriculture & Forestry, Government of enumerators and in other capacities. After the establishment of this system, the crop sampling survey was made for the first time in Japan.

After World War II an emphasis was laid on research on fisheries stocks, and it was felt necessary to obtain more accurate fisheries catch statistics than before. A new provision was made in the national budget for 1950 for fisheries statistics work and regular fisheries surveys were also included in the Statistical Survey System of the Ministry of Agriculture and Forestry. One thousand employees were engaged in the Statistical Research System to attend to enumeration and other items of fisheries statistics; that is, 40 persons in the Central Bureau, 260 in the 41 prefectural offices and 760 in the 400 branches along the coast. Accordingly, in August 1950 the Fisheries Statistics Section was newly organized in the Central Bureau, and from 4 to 10 officers were attached to each Prefectural Statistical Survey Office and one or two persons to each of the Coastal Branches.

3. **Present status.**—After the establishment of the Statistical Survey System mentioned above, fisheries statistics in Japan has developed systematically from year to year. The statistics which are being collected at present can roughly be divided as follows: (i) Statistics of Fisheries Production, (ii) Statistics of Aquicultural Production, (iii) Statistics of Processing, (iv) Statistics of Fisheries Structure, (v) Statistics of Fishery Finance, (vi) Statistics of Price.

(i) *Statistics of Fisheries Production*

The fisheries of Japan may be classified as follows:

1.1 Marine fisheries
  1.11 Whaling (including mother ship type)
  1.12 Mother ship type fishery for tuna long-line, salmon and crab fishing
  1.13 Domestic marine fisheries
1.2 Inland water fisheries

In the whaling and the mother ship type fisheries, the number of fishing units is small. They operate on the high seas, and must observe international laws and conventions. A supervisor of the Fisheries Agency is always on board during fishing operations and the statistics of production are collected by him.

The group 'Domestic marine fisheries' consists of various types ranging from the large pelagic tuna for which longlines and steel boats of 200 tons and over are used, down to the miscellaneous shell-fish collecting without special craft. It is therefore difficult to obtain accurate statistics of production. These statistics have been handled monthly by the Statistical Survey System of the Ministry of Agriculture and Forestry since April 1951. At
this survey has mostly been completed in co
and accuracy, and 80% of total catch has
surveyed by sampling method. Immediately af
sampling survey had been applied to the crop
in 1947, a pilot survey on catch statistics was
out in Fukuoka prefecture from 1948 to 19
sampling methods and the result was help
the pursuit of a large-scale, nation-wide sur

In the beginning of this survey, it was fe
the catch statistics in the past had not been
And, in fact, the statistics relating to 1951 an
related only to the quantities of fish landed.
realized that even though the figures for
two years might be more or less reliable, they
indicated the tendency for the production to
or decrease. The need was felt for survey
number of fishing units and the fishing e
correlate with the production. Moreover,
fishery units differ in size, the size of the bo
be taken into consideration.

Since January 1953, these items have
surveyed and the results compiled in the
Reports on Statistics of Marine Fishery C
The annual total number of trips per fishin
the annual total catch per fishing unit and the
catch per trip of the unit for the year are all in
in this Report. It is hoped that if the sur
continued for a number of years, such data
of substantial use in assessing the resource
planning their management.

Although the amount of catch from inland
fisheries is less than 1% of the total fish ca
Japan, it is quite important since the catches in
high class and expensive fishes such as th
carp, trout and so forth. However the sur
inland fisheries has not been systematized an
the quantity of production by kinds of fish is
mined once a year by interviewing fisheries co-
tives. Since 1952 surveys of catches from
and lakes are being attempted in different prefe
It need hardly be stressed that each river
forms a distinct unit irrespective of prefect
other artificial boundaries and hence its fish
to be surveyed as a whole.

(ii) *Aquicultural Statistics*

2.1 Aquiculture in Shallow Seas
2.2 Aquiculture in Inland Waters

As in the case of the Japanese inland fisheri
general, aquicultural statistics are collected
once a year as was the case with marine fish
prior to 1950, though aquicultural statistics re
to the shallow seas have been brought under mo
survey since 1953.

wing items should be covered in aqui-
veys :
number of operating units producing
a) different stages of juvenile stock such
s ova, larvae, fry, fingerlings and young
fish, and (b) mature crop of food fish
ount of food and aquatic manure utilized
ltivated area and production per unit
area. In the case of oyster culture, the
number of rafts and collectors is
significant
groups of the harvested crop.

ics of processing

nately 70% of the total catch in Japan
for processing. The statistics of
are therefore quite important. At present
is carried out by interviewing the
units of domestic establishments, co-
and processing factories once a year, and
items are concerned only with the number
hments and the quantity by kind of
The organization and technique of the
of processing statistics has yet to be
in Japan.

wing points should be taken into account
er processing survey :
h processing is one of the important links
in the chain of fishery activities from the
stage of catch to that of consumption.
The survey items of processing should
therefore be determined in close association with the statistics of production and
consumption.
ce most of the catches are usually assorted
at the landing place into fresh fish for
immediate sale and fish for processing,
the quantity used for processing could be
enumerated at the time when the survey
of the catch is made.

ics of the structure of the fishing industry

n 'fisheries census' is considered to
e number of fisheries establishments,
fishing boats, quantity of catch, value
personnel in fisheries establishments,
occupation etc. Some information
hese items is no doubt available in the
hered by the Central Statistics Bureau,
not adequate for purposes of fishery
Japanese fisheries range from the subsis-
up to those using steel boats of over
in the trawl fishery, tuna longline and
ip type whaling. The survey of the
hould therefore cover the following :

(i) Kind of management organizations :
  Individual management
  Co-operative organization
  Socialized organization
  Company
(ii) Kind of fisheries mainly operated throughout a year
(iii) Scale of management
  In Japan this index has been classified by total tonnage of fishing boats which the management unit has owned ; sometimes one management unit possesses more than one boat.
(iv) Number of workers (a) Full time or (b) part time
  In case of part-time works the nature of subsidiary occupations must be considered.

A fisheries census was carried out for the first time in 1949 and again in 1954. In the future such a census will be taken every five years.

Owing to the lack of adequate personnel in the Statistical Survey System of the Ministry of Agriculture and Forestry to interview all management units, both the fishery censuses mentioned above were carried out through the prefectural governments and city or village offices except that in the 1954 survey the special type management units such as co-operative organizations, company and fisheries schools and experimental stations were more fully covered. The 1949 survey was done on the reporting method, that is all fishermen in Japan were required to fill in the survey form, but in 1954 interviewing by the enumerators appointed on a temporary basis was adopted in order to avoid the errors involved in self-reporting.

The first effort at a fisheries census had its limitations especially in view of the social confusion following World War II and the defects inherent in the self-reporting method. In the second fisheries census, however, the definition, classification and selection of survey items were well determined taking into account the experience of the first census with the result that the data obtained are more reliable. Nonetheless, since almost all of the enumerators engaged in the second fisheries census were inexperienced in fisheries statistics, considerable errors have crept in, especially in the listing of management units.

In the light of the experience of these two surveys, it should be emphasized that in the ensuing third fisheries census attention should be paid to avoiding omissions or duplications in cases where the list of survey objects is to be made by enumerators. The actual survey in the field should therefore be conducted by skilled enumerators.

(v) *Statistics of fisheries finance*

This survey was commenced in June 1951. At present, 500 sample fisheries management units each of which uses a boat of less than 10 tons and 200 sample units each of which uses a boat of over 10 tons, are surveyed. These sample units have been required to record the receipt, expenditure and working status in detail every day during the whole year. As the structure of the Japanese fisheries is very complicated as mentioned in (i) and (iv), the economic status differs widely according to the scale of fisheries management, the kind of fisheries etc. Due to the fact that most of the fishermen operating their own fisheries do not usually keep any record of their income and expenditure, the enumerators of the branch offices have to go to the sample units at least every ten days, and sometimes they are obliged to revise or complete the records. In view of these limitations it is very difficult to increase the number and size of the samples.

(vi) *Statistics of price*

The statistics of price at the landing places where fishermen sell their catches is extremely important in the estimation of the income of the fishermen and in attempts to enhance it. In Japan, the consumers receive fishery products after they have passed through three to five middle agencies. Since all the catches are not sold through the fish markets at the landing places and since the price of fish fluctuates in the course of the day even at the same place, it is not easy to record the prevailing prices. However, in view of the recent improvements in transportation, the price will depend consid on the amount of catches landed. Theref pilot price survey has been set up since the begi of 1955 at 57 fish markets at landing places and wholesale markets in big cities. The price by s in this pilot survey is calculated as the wei average.

Conclusion.—In designing fisheries stat surveys the following points have to be bor mind:

(1) Specification of the purpose of the su
(2) Determination of the items to be surv

In any statistical survey, there is a main su to be surveyed, such as the quantity of prod in the crop statistics or the volume of catch fishery statistics. The statistical table will be h in recording details of various items related t main subject. In addition, after careful deter tion of the survey items, the statistician should up a form to be filled in by the surveyor and completed by the collector. The purpose utility of the survey will be self evident in the

(3) Definition of survey items.

The definition of the survey items should be as clear as possible so that the enumerators understand and identify them in the field. example, in the case of the number of trips, wh in the coastal fisheries one trip a day is usuall rule, the beach seine makes many hauls a day. the limited personnel and facilities available, impossible accurately to count every haul an the number of fishing days is taken to repr the number of trips.

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ME BASIC PROBLEMS IN THE DEVELOPMENT OF FISHERIES STATISTICS IN JAPAN

by

N. Oka*

ous efforts are being made by administrative have accurate statistics. But how much statistics used for the proper purpose of tion ? ' This doubt was one which was rmost in the minds of people concerned stical work in Japan, especially by those specialized in fisheries statistics.

s were in fact in many cases considered re decorations to administrative activities s, and plans were apt to be based on theory n on statistics or data. Even when statis- referred to, they were often disregarded und of their unreliability. On the other n among people considered to have a of statistics there were some who appraised the numerical value of official t 50% or 30% of the real values. In this uthority of statistics was for a long time ated, despite the efforts of statistical

nisconceptions have not been entirely even today, but through the drastic social d reconstruction carried out during and var, a general demand for basic statistics e apparent. Because of this and of the ances in the theory and practice of statis- kepticism regarding the value of statistics considerably reduced.

have come to disregard any argument naccompanied by statistical evidence and easingly recognized that concrete pro- an be planned only on the basis of actual same can be said in the field of scientific In the field of natural and social sciences stated that scholars who do not have the mathematical background find their estricted. But can we definitely say that re to-day properly utilized, either in r administration ? Are not statistics as t used merely to demonstrate the validity ment previously established or a plan or rarily decided ?

l be a happy circumstance if such were se, because statistics in the true sense should not be compiled for any such purpose. Serious reconsideration is called for regarding the current easy way of thinking about statistics, not only on the part of scientists and administrators, but also on the part of statistical workers themselves.

We are told that ' statistics tell all about things '. For example, one mean value may contain several numerical values. But its users may not know this. If at least its dispersion were mentioned, the significance of the mean value would be clearer. And in the case of a great dispersion, there may be such values that should be divided into several mean values. When statistics are used in this way, who can be sure there is no danger of misinterpretation or misunderstanding ? Certainly there is great risk that such statistics will not serve their true purpose of counteracting false subjectivity or policies of expediency but that they may rather give support to them. It is very important, therefore, that fisheries statistics should always be differentiated by species, types of fisheries, fishing areas and economic scales.

It is also said that ' statistics always tell the truth '. The basic data of fisheries statistics in Japan are collected by a specific statistical organization independently from administration or research. To this extent it may be maintained that the Japanese fisheries statistics may tell the truth. But, even assuming that the statistics have been correctly compiled, they will only tell the truth insofar as they are specially designed to answer specific questions. If they contain elements foreign to the answer required, they may not always be truthful.

The margin of error in fisheries production statistics in this country ranges from 5% to 20%. Although such statistics may not always be sufficiently precise for use as data for scientific research and administration, they are through necessity often used for some improper purpose. In such cases, it is of course the users of the statistics who should undertake to ascertain the truth by collecting other comparable statistics as a control. But on the whole, statistics compiled for a different purpose, or which are of a precision inferior to that

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ries Agency, Government of Japan, Tokyo, Japan.

required, cannot be expected to meet the new requirements. If a conclusion is at all attempted, it must be confined within narrow limits and the degree of accuracy must be defined.

Compilation of statistics being conditioned by such factors as expense, number of personnel and time, it must be admitted that their accuracy has a limit both in theory and practice. All that can be expected of such statistics which may have reached the limit of precision is to continue them over a long period of time, and on the other hand gradually to complete a series of statistics closely correlated to them. This will not only improve the accuracy and depth of the former statistics, but will also make the series of related statistics more perfect. In this way, the reliability of the statistics will be promoted, their users will be relieved of doubt and the particular purpose pursued will be better served.

The role of statistical workers is not only to collect scattered information, but also to examine the accuracy of their methods and to review their precision at different levels.

Whereas other disciplines in the fields of fisheries or social sciences themselves attempt to establish certain scientific or social principles, and whereas administration and industry undertake the practical application of those principles, it is the aim of the statistician to provide data for the use of other sciences and activities. But since the application of statistics is limited according to the object for which they were originally collected, it is necessary as far as possible to undertake the collection and tabulation of statistics in each case so as to serve the specific end in view. In special statistics of this kind, statistical workers must of necessity make a study of the principles involved or the purpose of the administrator in requesting them, in co-operation with the competent scientists and officials.

It can, therefore, truly be said that 'statistics should be taken at a request of their users'. But although this may be admirable in theory, it must be accepted that national basic statistics are, in fact, compiled for the use of many different categories of people and that they can in practice only rarely be taken at a request of special users. They can, however, be taken according to the requirements of the majority of users.

There is also a saying that 'Statistics generally increase their value only when taken continuously'. This would appear to mean that the statistical methods used should remain constant and in general this may hold true. But there are other cases where objects have so changed that it becomes imperative to vary or improve the method of surveying, or where the object pursued when designing the earlier method has become modified. In such cases, continuity of method is not so important as kee abreast with the object in view and ascertaining changes which it may have undergone.

The science of statistics has, with the develop and co-ordination of other sciences, created n new methods and theories of its own. In ac planning, nevertheless, co-operation betw statisticians and scientists is essential.

There are many fisheries questions which req the application of statistics for their solu Among these, the most basic and important are study and application of biological principles gov ing fluctuations of catch and the economic underlying the development of fisheries.

It is, of course, true that the study of the history and ecology of fishes must commence the study of individual fish, but it becomes esse to introduce statistical study when a cer numerical limit is reached. The determinatio fish population as a unit of a resource, the stud its migration or of the relation between the s of fish and fishing effort bearing on it can be acc plished only by further development of fish statistics.

If such statistical data were all to be collecte fisheries biologists, a great number of experts wo have to be posted throughout the country, and s an organization would undoubtedly overlap special national organization for statistics. In Ja large-scale statistics which aim at obtaining ex sive numerical values are taken by the nati statistical organization, while medium-scale statis are attempted by smaller statistical units under guidance or direction of biologists.

Statistics of fisheries production is perhaps most valuable item in this field, which is condu by the national fisheries statistics organizat The production statistics are taken according the figures of landings, which are broken down three types: by species, by types of fisheries and combined types. They are compiled every mo in all prefectures. Although it has been and is arduous task to compile the voluminous landings three types every day, it has been accompl through the efforts of statistical workers over m years.

The next important work which must be acc plished by the specific organization will be a se of statistics by fishing areas (catches by spec types of fisheries and by seasons), because th statistics have a close relation not only with production statistics as mentioned above, but with the fishing effort statistics required determination of measures for the conservation sources, which is one of the primary of fisheries science.

statistics concerning fishing areas or nd fishing effort are now being taken by workers in Japan. But since special aken by fisheries biologists have a very range, it is thought that such statistics g fishing areas or fishing effort, which can l out only by the enumeration of vast plicable to various purposes, should be ned by the special national statistical on.

tistics of the economic development of ies reflect changes of the structure of production. The ' Fisheries Census ', conducted once in five years, clarifies this ince the items of this national census numerous fisheries enterprises, fisheries d part-time fishermen, means of production the result obtained by the census will ny change in the basic structure of the hroughout the country. Parallel with the e ' Economic Survey of Fishermen ' is ducted monthly. The status of small nanagement and living standards of fishing who are mainly responsible for fisheries in the Japanese coastal waters, is d by means of this sampling survey.

wo types of statistics are taken by the tional organization for statistics and they esearchers in fisheries economy with ata essential to the knowledge of the secular the fisheries. But all aspects of fisheries cannot be fully understood from these . The economics of the fisheries in ters must be studied by specialists in those of other waters broken down by sheries and types of enterprise and with ed industries.

s in the case of fisheries biologists, the are now taking many statistics in the ield of fisheries. National scale statistics ose connection with the Economic Survey nen, such as the survey of living expenses abourers or the status of management of isheries enterprises must, however, be y undertaken by a specific national n for statistics, because the study of the n and of the complex circumstances fisheries economics can only be developed nproved statistics supplied by such a ganization, having at its command information on fish prices, transportation, storage, n, fisheries finance and cost of production.

gard to the statistical requirements of ministration, the completion of the above-mentioned basic statistics will help a great deal towards the formation of plans for harmonized development of several aspects of the fisheries including increased productivity. But the great complexity of modern fisheries administration demands that the most pressing problems receive prior consideration. Appropriate administrative action must be taken, when necessary, for co-ordination with other related industries ; for emergency and permanent measures for artificial and natural accidents ; for the establishment and maintenance of national and international fisheries regulations, for the encouragement of research on new fishing gear ; for the modification of small fishing boats to meet new conditions ; and for the improvement of labour conditions, the formation of fishermen's co-operatives and other joint enterprises etc. The introduction and enforcement of plans for these pressing problems and the appraisal of their results require detailed statistical data of a special kind.

When such statistics are not already collected by another agency, the administrative office prepares them on the basis of information collected from local governments, fishermen's co-operatives or fishing firms. This information is collected either by legal regulations or by simple inquiries. In either case, however, as it is done by correspondence, there are not a few cases where the rate of reporting and reliability of data are very low, either because of the negligence of reporters or for other reasons.

Commercial statistics of this kind are common in Japan because the desired data can be easily obtained and the procedures for preparation and enumeration are comparatively simple. This kind of statistics is often fairly reliable especially where the compilation is regulated by law. In other cases, where the statistics are compiled by all sorts of administrative organizations, their character and veracity vary a good deal, and their impartiality is sometimes in doubt.

It is therefore important that these statistical data be used for specific purposes only by those who are well aware of their nature, and that such of these statistics which are liable to be used by others should be transferred to the special statistical agency of the Government as soon as possible, first taking those statistics having a close connection with basic statistics already established.

The advancement of fisheries statistics is closely linked with the development of science and administration. The history of fisheries statistics in Japan over the last quarter of a century is as follows :

Early period.—Fisheries science engaged mainly in studies on individual specimens without referring to statistical data, while in the field of administration the Government also concentrated its efforts on the consideration of the affairs of individuals.

Such fisheries statistics as existed were based on the items used for statistics of other industries and fisheries statistics of foreign countries, and the collection of data was carried out mainly on the basis of written information. They were planned independently from the administration and science of the country at that time, and no systematic development could therefore be expected.

Intermediate period.—Statistical method of study was increasingly used in biology and other fisheries sciences, and the deduction of principles and rules by mass observation became an established rule.

This period covered the time before and during World War II, which was called ' the period of controlled economy '. Considerable use was made of statistics in most fields, including the administration of fisheries. Fisheries statistics were compiled according to plans mapped out by those scientists and executive officials concerned with the ' controlled economy '.

Present period.—After the war, fisheries science has made great progress. The stage of simple mass observation has developed to the stage where fact-finding and recognition are intensified through the analysis and synthesis of statistics. This has also contributed in great measure to the develop
of fisheries economics.

Basic statistics at the national level are now u
taken by a special, independent organization.
workers in this organization, in co-operation
scientists and administrative officials, are
efforts towards the development of fisheries sta
through increased recognition and understand
the fisheries problems.

The scope of the special organization for fish
statistics at present covers about 4,000 fishing
and approximately 250,000 operators ; the stat
items include the daily production of fish by sp
by types of fisheries and by tonnage of fishing
and include the socio-economic study of fisher
households, in addition to ' Fisheries C
conducted once in 5 years.

The time has now come when officials in
of the preparation of statistics should,
necessity arises to take up new items for s
size up the trend of science and administratio
then gradually seek the rational developme
adequate statistical methods most closely rela
those already established, rather than merely
with other's requests.

Some general improvement in fisheries sta
is required, but it is believed that accuracy,
standing, specialization and continuity are the
elements which will ensure the developme
statistical investigation.

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THE RELATIVE IMPORTANCE OF SUBSISTENCE FISHING IN INDONESIA

by
M. Ahjar*

here in Indonesia and in every type of
th subsistence and commercial fishing are
n. It is, however, difficult to determine
ive importance of the former, because
o clear distinction between subsistence and
al fishermen. Often, the main object
called subsistence fishermen is to obtain a
me. Only in remote areas subsistence
ight take an important place, but even so,
f fresh fish to obtain money for purchasing
l dried fish is common.

This paper will attempt to give an idea concerning the relative importance of subsistence fishing in some parts of West Java, and one can find the same picture in other parts of Indonesia.

Fish production in inland fisheries.—Inland fisheries activities in Indonesia consist of fish culture in brackishwater ponds, freshwater ponds and rice fields and fishing in every type of water, including rice fields.

The fish production in the different types of inland fishery in Indonesia for 1954 is as follows :

Brackishwater ponds	(128,000 ha.)	29,000,000 kg.
Freshwater ponds	(20,000 ha.)	24,000,000 kg.
Rice fields	(65,000 ha.)	9,000,000 kg.
Lakes, marshes and rivers (?)		165,000,000 kg.
		227,000,000 kg.

duction in ponds and rice fields is mostly
vation, whereas that from lakes, marshes
is principally from capture operations.
clear from the figures given above that
two thirds of the total production comes
ng. This is specially true in the islands
ra, Kalimantan (Borneo) and Sulawesi,
e rivers, lakes and marshes are of relatively
tance in Java.

ificance of subsistence fishing

islands other than Java

lands are sparsely populated in comparison
and are not yet industrialized, so that the
es and marshes are important sources of
l species for export to Java after

island of Java

is carried on not only by professional
but also by persons who fish only
y. It is difficult to differentiate between
fishing and commercial fishing. Some
of these combined operations are given

kishwater ponds : *Chanos chanos* is
in brackishwater ponds. During the
cultivation period there is always some fishing in the ponds themselves as well as in the ditches, for crabs, shrimps and extraneous fishes. The yield from the ditches is for the fishermen, but that from the ponds has to be shared with the pond owner on a fifty-fifty basis. In the area of Ambulu (Tjirebon, West Java) the average annual yield of this kind of fishing amounts to 200 kg. from a pond area of 1,115 ha. Fishing is done by the pond owners themselves, the caretakers or other persons. There are 40 persons practising this kind of fishing during the whole year, 20 days a month. Among them 25 per cent or 10 persons are professional fishermen who get their daily income therefrom.

Twenty per cent of the yield is used for private consumption, while 80 per cent is sold. The fishermen never consume the required quantity of annual protein and when they have an unlucky day, they do not hesitate to sell the whole yield, as they need the money to purchase rice. The yield is mostly sold to collectors, to whom most of the fishermen are already indebted.

(*b*) *Brackishwater swamps :* There are many swampy areas along the coast not yet converted into fish ponds. In these places fishing takes place regularly. As an example, the area of Pabean-ilir on the north coast of West Java, with an area of

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r, Inland Fishery Service, West Java, Indonesia.

1,400 ha. may be considered. There are 260 fishermen, among whom 200 are professionals and 60 persons doing fishing as a secondary occupation besides farming and firewood collection. Fishing is done during the whole year, 25 days a month. The yield consists of shrimps, extraneous fishes and sometimes also *Chanos chanos*. There is some difference between the daily catch of a professional fisherman and that of an occasional one. For the former, the average daily catch is about 5 kg. and for the latter about 2 to 3 kg. Only a small part of the yield is apportioned for private use, and as in brackishwater ponds, the greater part is for sale, again to collectors, so subsistence fishing has here also a limited role.

(*c*) *Rice fields :* In rice fields in the period between harvest and the succeeding rice cultivation, fishing of eels (*Monopterus albus*) is often done by professional fishermen. For this purpose they use eel baskets (*posong*). Each person lays 50 to 60 traps every evening and these are collected in the morning. The average yield is one eel per trap. Each fisherman can catch about 1½ to 2 kg. a day. In the sub-district of Bodjongloa (Bandung) there are 25 persons living on this kind of fishing. The yield of eels is about 3 to 5 per cent of the whole fish production of the sub-district. The value of the daily catch per person is Rp. 6. The whole fishing is commercial, because the fishermen themselves do not eat the eels.

(*d*) *Lakes :* In small lakes, cultivation is carried on by co-operative societies or by the village administration service. In uncultivated lakes, fishing is conducted by professional fishermen and occasionally by sport fishermen. In the lake of Bagendit West Java, (70 ha.) for instance, fishing is done by all the people of the village near the lake (350 men and 150 women). Fishing is carried on by day and by night throughout the year. Only
2 per cent of the villagers are occasional fishe
Most of the fishermen use about 40 per cent
yield for private consumption. Some fisherm
the whole yeild and with the money obtaine
purchase other kinds of fish products such as
fish, cured or canned fish, etc. The yi
occasional fishermen is usually consumed by
selves.

(*e*) *Rivers :* Rivers can be divided into tw
tions, i.e. the higher course and the lower
In the higher course mostly occasional
(game fishing) is carried out. In the Tjitarum
one of the biggest rivers in West Java, there
the higher part (a stretch of about 120 km
fishermen, among whom only 5 per cent ar
fessionals. In the lower part (a stretch of 5
however, it is just the opposite: 95 per cen
fessional and 5 per cent occasional fishermen
catch about 3 kg. and 1 kg. per day per ma
pectively. The species caught are; Carp, *H*
Osteochilus (mostly escaped from ponds), *Labeo*
and others.

The professional fishermen sell 80 per c
their catch and consume about 20 per cent wh
occasional fisherman consumes 100 per cent
catch.

(*f*) *Marshes :* Commercial fishing is the
activity in marshes also. Not more than 20 p
of the yield is used for subsistence. In the
Lakbok one of the largest marshes in Wes
(1,100 ha.), fishing is conducted in the dry
when the water level is decreasing. Fisherm
mostly persons who are engaged in agriculture
the rest of the year, but who during the
season leave all other jobs and catch fish fo
four months. The annual yield is about 60

SECTION III

Containing Technical Papers presented at and the report
on the Symposium on Prawn Fishery held during
the 6th Session of the Council

1

REPORT ON THE PRAWN SYMPOSIUM

rawn Symposium held in connection with th Session of the Indo-Pacific Fisheries at Tokyo on October 5,6, 1955, highlighted ortance of the prawn fisheries to the whole d the apparent lack of exploitation of the resources as well as the very limited develop- prawn culture. The eighteen papers from ıber countries dealt with biology and ecology, techniques and cultural operations, utiliza- l marketing, and general descriptions of s of the fishery.

A. RESUME OF DISCUSSION

eral Biology and Ecology

hilst life history studies have reached an l stage in certain countries, the biology of e important species in the central sector uires extensive study, in order to render ore fisheries more productive and to develop fisheries and cultural practices in suitable The large unsatisfied demand from fisher- live prawns for bait suggests the urgent devising measures to meet it. The adop- ultural techniques would appear to suggest n to this problem, further work on which utmost importance in the region.

ertain tagging techniques were referred to, lopment of which is likely to be of great e in the study of migrations and growth ormation on which will assist in the rational n of all available stocks.

was considered that a study of the reactions ıd adults to lighting of different intensities ours would be fruitful in developing es for collection of fry for cultural work, capture of adult stocks.

study of the controlled artificial raising om spawners captured in the sea indicates cess is dependant on the adequate supply ppropriate food for each of the stages in wth of the prawn. Moderate success has ieved on a laboratory scale in Japan, and being directed towards establishing es for adoption on a commercial scale.

ıe enormous potential value of this fishery common to the whole area was stressed, as of the few groups of marine animals of importance which can be cultivated in ies in the region.

II. Capture and Cultural Operations

7. Nearly all operations described refer to the inshore fishery. It is apparent that there is a tremendous field for development of offshore resources and cultural techniques. The offshore fishery should be developed, keeping careful records of catches from both offshore and inshore fisheries. While biological investigation will probably throw light on this subject, the present state of knowledge tends to indicate that there is no danger of a drop in inshore yield as a result of intensive offshore fishing.

8. Cultural practices range from attracting young prawns into growing ponds for subsequent capture to the collection of fry from the sea and their introduction into growing ponds in the desired quantities. The alternate use of rice fields for prawn ponds in a rotation of crops during the dry season indicated the prospects for the fuller utilization of land which is suitably located, thus giving the farmer a protein crop and an additional source of income. The wider adoption of this technique awaits further information on the effect of this rotation on the rice crop.

9. The use of tides as a means of collecting prawns in ponds for ready harvesting of the larger stages may afford a means of production in areas where there is an appreciable rise and fall of tide.

III. Utilization and Marketing

10. The general consumer preference is for whole prawns in fresh or iced condition, and the market is largely undersupplied. In a few regions where production exceeds demand, prawns are either sun-dried, or parboiled and dried for export. The chitinous portion is removed in processing and crushed for poultry feed.

IV. General

11. There is possibly some relationship between rainfall and prawn yield which will repay fuller investigation.

12. A number of taxonomic field keys have been produced and it was suggested that these should all be consolidated into one general key for the region. It was decided that the term prawn should be applied to the Penaeids, Pandalids and Palaemonids, while the use of the term shrimp should be restricted to the smaller forms belonging to other families.

B. RECOMMENDATIONS

I. Biology and Ecology

13. A rapid evaluation should be made of the salient features of the life history and ecology of local species, in relation to information available on similar species which have been carefully studied in countries outside the region.

14. The study of the effect of such stimuli as sounds of different wavelengths, chemicals, electricity, and light of different colours and of varying intensities on adult prawns and fry should be undertaken as a means of developing new techniques for catching.

15. It may be necessary to begin collecting data on rainfall and meteorological conditions which may be of significance in determining prawn yields.

16. Careful investigation is necessary to determine specifically whether it is necessary for the prawn to return to the sea to complete its life cycle.

17. The Japanese work on the rearing of prawns under controlled conditions from egg to adult and the culture of *Skeletonema* for feeding the larvae stimulated great interest. This work should be watched closely, and full facilities afforded for reporting on progress to member countries, as this technique will, in addition to cultural m
provide necessary material for behaviour s

II. Capture and Cultural Operations

18. The exploration of offshore areas for l
of fishing grounds in likely localities shou
undertaken, together with the developme
suitable gear and capture techniques.

19. The introduction of cultural operati
regions where they are unknown, and the c
and supply of fry for stocking culture ponds,
be undertaken. This will give a ready solut
the problem of bait supply for fishermen
operations are dependant on the use of live p

III. Utilization and Marketing

20. No marketing problem has been recog
Work which is now in hand on handlin
processing techniques appears to meet present

IV. General

21. In order to achieve maximum utili
it is necessary to maintain accurate reco
catches by sizes and areas of capture.

22. It is recommended that Professor
should be invited to prepare a standard field
identification of species of prawns and shri

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THE PRAWN FISHERIES OF CEYLON

by

E. R. A. de Zylva*

Fishing for prawns has been carried on in Ceylon's lagoons and estuarine waters and along certain parts of the coastline from the earliest times. The principal methods in use for the capture of prawns cannot be said to have undergone any significant development in recent times. They are simple and reasonably effective within certain limits, and the equipment is locally made of locally available material, at no great cost.

Prawns find a very welcome place in the local diet, and command a ready sale at prices which are sometimes above the reach of the average man, because demand nearly always is far greater than supply. Apart from their use as food, a great number of prawns is required daily by fishermen for use as bait, both in live form and dead. Certain ty
inshore marine fisheries cannot be conducted w
live prawns for bait, and there is a close bu
relationship between the prawn catching fish
and the sea-going fisherman ; the latter receiv
prawns from the former and pays for these by
him a fixed share of the value of the catch o
This share varies, but may be over one-fiftee
the value of the catch.

The methods of capture range from the si
form of feeling with the hands in the fine m
the lagoon bed to the use of extensive fen
screens, or traps, or stake nets set to capture p
on their migration up or down channels
connect lagoons with the sea. The latter are

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* Deputy Director of Fisheries, Colombo, Ceylon.

association with flares during the night to the prawns ; catches are best on moonless

simpler methods, such as the purely manual referred to above, are carried out at a ence level by dwellers beside lagoon. There an ingenious device resorted to by children reation with profit. They clean the mid rib conut leaflet and fashion the fine flexible end nto a noose. They then wade cautiously, deep, in the lagoon shallows and mangroves, k for the protruding eyes of the prawns, the of which lie hidden from view, buried in t silt of the lagoon bed. The noose is then placed on the eyestalk and drawn tight, and agitated prawn is fished out of its lair.

nets, so characteristic of this region, are s the most widely used instrument for the of prawns. They are used both by waders shallows and by men in little dug-out canoes, r without an outrigger. In one particular on the northeast coast, which loses its tion with the sea after the North East Monover, about March or April, a very profitable fishery commences about June, when the evel begins to go down in the land locked and the fishery continues for about two . Here the prawns, unable to return to the w to an enormous size, and a single cast net an, selling his catch at 6 cents a prawn, rn Rs. 90/- on a good night. This centre 200 miles from Colombo, where these same may sell at 15 or 20 cents each.

any estuaries and lagoons, where a rise and he sea tides causes a definite ebb and flow, ets and fence traps or kraals are used. The ets are made of cotton or hemp, generally o wings and a bag, and are fixed in carefully sites, just before the ebb tide commences ; a bright kerosene flare is lit just above the e to the net, and during the ebb flow the is periodically emptied into the attendant r canoe which remains secured to a stake located beside the bag. This operation also o clear the net of leaves and brushwood which ome down with the tide. The canoe used fishery is quite unlike the better known or sea-going type of outrigger canoe. This fishery is found in its most highly developed Negombo lagoon, 20 miles by road along t north of Colombo.

kraal, which might be described as a screen, of a wall made up of strips of bamboo, e centimetre in width and four feet long, re tied together with coir rope into tats half centimetre or smaller gaps between the slats. These tats are fixed to supports made by planting poles in the river or lagoon bed and cross-bracing them for support. At intervals in the fences small gaps are left which lead into heart-shaped chambers constructed of the same material, the entrances to which are very narrow. At night, flares are suspended above these entrances. The prawns and fish, enticed into these chambers, are collected from time to time. One never knows what one is likely to find, in addition to the prawns—sometimes a young crocodile is found in the chamber ! These kraals too are fixed at carefully selected sites, where the depth and current are suitable. There is considerable difficulty in controlling the activities of kraal fishermen, who surreptitiously extend their fences under the water level until they stretch unbroken from bank to bank. The uncontrolled use of kraals has in some waters resulted in depletion of stock and diminishing returns.

In certain areas of the coastline, notably off the north west coast, where much mangrove formation provides extensive growing grounds for prawns, considerable catches of penaeid prawns are made in beach seine nets cast in the sea and drawn on to the shore.

The presence of such an abundance of prawns indicated the likelihood of there being a breeding ground at some distance from shore ; developments in other countries, notably in the Caribbean area and off Chile, where prawn fishing grounds have been found in recent years, coupled with the high commercial value of prawns both for local use and for export trade, have indicated prospects for a new fishery in offshore waters. By a chance accident, one of the Government trawlers found a potential prawn bed. These trawlers have spent most of their time fishing on the Wadge Bank, some 4,500 square miles of trawlable sea bed lying off the southernmost tip of India and some 150 miles west by north of Colombo (Appendices I and II). The weather can often become too heavy for trawling off Cape Comorin, and on one such occasion, during the South West Monsoon, the trawler was taken further inshore in a north easterly direction into the lee of the land. Here, finding about 10 to 15 fathoms of water, and conditions not too unfavourable for fishing, a few trial hauls were made. One of these yielded over half a ton of large sized penaeid prawns. The gear in use was not suited to the capture of prawns—the standard Granton trawl. During the hauling, when the net came alongside, large numbers of prawns were seen to be escaping through the meshes of the net and swimming away ; it is conceivable that a much higher yield might have resulted if a shrimp trawl with about 16 mm mesh had been in use. However, it has not been commercially advisable to divert the trawlers to these grounds, until suitable gear has been secured, and satisfactory measures developed for the storage of catches. The trawlers are equipped with refrigerated and insulated fish holds, in which gutted and washed fish are packed with ice, and keep in excellent condition over a ten days' trip, but prawns may require different treatment.

Further investigatory hauls were made in this area whenever trawlers had to run in for shelter, and present indications reveal the existence of an area of mud bottom at a depth varying from 9 to 15 fathoms, about 10 miles south of Manapad light on the South Indian Coast. The best fishing was at a depth of 14 fathoms during a westward tow, which yielded 22 baskets of prawns. Prawns have been found on this ground during the South West Monsoon only. This accords closely with conditions existing on the west coast of Ceylon, where some of the rivers and lagoons in which prawns are found are land-locked until the heavy rains in April or May, at the commencement of the Monsoon, restore their communication with the sea. It is therefore possible that a migration of prawns from the west coast of Ceylon commences during the early part of the South West Monsoon, and that the breeding grounds are located in the sea between the south east coast of the Southern part of India, and the west coast of Ceylon, in the area of the sea known as the Gulf of Mannar. This is a matter for further investigation.

Since the original encounter with prawns on these grounds, subsequent trials have served to strengthen the evidence that prawns can be trawled there during the South West Monsoon season. Experimental work with a 12 ft. shrimp beam trawl used from a 28 ft. powered fishing boat is being planned for assessing the prospects of developing a fishery with small powered craft. The trawls have been purchased from a firm in Denmark. Waters closer inshore are to be examined.

Prawns are at present marketed in the whole condition, whatever their size. Consequently they do not keep very well, and must be sold as soon after capture as is possible. Experimental work was initiated at the centre on the North East Coast, referred to above, where very large sized prawns are caught in numbers during the June-July period. This centre is a whole night's journey away from Colombo. Prawns, which are captured in this lagoon principally at night, reach the packing centres early on the following morning. There they are packed whole, in crushed ice, in wooden cases, and there they remain under jute hessian covers until the evening, when they are re-iced, if necessary, and despatched by road and rail to Colombo. They appear in the markets on the next morning, that is anything between 24 and 36 hours after cap
An ice making factory operates at the packing ce
and, by arrangement with the owners, a consign
of these large prawns was taken, the heads remo
the tails washed in water and packed into a stan
½ cwt. ice making can; they were pressed well d
and the air evacuated by addition of just suffi
water to cover the flesh. A board was placed o
prawns and weighed down to keep them fi
packed in the can, and the can was put in the free
tank. The pack was frozen solid in about 12 h
and was despatched to Colombo, packed in a
hessian cover. It arrived in good condition o
following morning, though some of the ice
melted. The block was transferred int
refrigerated fish storage room at about 20°F
the prawn tails were kept in excellent conditio
two weeks, after which they were found to
suffered no loss of quality or flavour.
demonstration showed the fish merchants that
could by adopting this method, save on ice
transport charges, as they would only have to tr
port the edible tails which occupy half the s
taken up by the whole prawn, and would get a m
better quality product into the market. But tr
tional methods and consumer preferences
take some time to change sufficiently to allo
general adoption of improved methods of han
and marketing.

Some work has been done on the biology of
more important species of penaeid prawns. M
still remains to be done, and work on this su
will be resumed when the Research Officer wh
specializing in this study returns after post-grad
training in the United Kingdom. It is clear
the most important species found in Ceylon's brac
waters breed in the sea. The location of t
breeding grounds and the determination of
details of their life cycles still await investigatio

While the study of capture methods and biono
is going forward, the culture of prawns in brac
water areas is receiving attention. In July, 195
Superintendent of Brackish Water Fisheries is ta
up duties in the Department. This biologist
with specialist assistance, endeavour to set
demonstration rearing ponds in suitable locali
He will study methods and seasons for attrac
wild immature stocks into these ponds, and the
period for harvesting the stocks. The rela
between these stocks and other species of estua
or lagoon fauna and flora which may occur in
ponds will also require study.

Mention has been made of a proposal to ex
frozen or canned prawn tails. With the pre
demand far exceeding the supply, it is unlikely
such a proposal will have good prospects until
supply position improves.

(*Quantities in baskets of approximately 80 lb.*)

Date	Time	Duration of tow	Shot in		Hauled in		Depth Fathoms	Wind	Force	Red Grey Black	Small	Seir	Shark and Skate	Leather jackets and Cats	Prawns	Total
			Lat.N.	Long.E.	Lat.N.	Long.E.										
9-7-53	1415	1¼ hours	8°-01′	77°-40′	8°-06′	77°44′	16-15	270°	3-4	9	2				7	18
9-8-53	0725	2½ ,,	8-13	78-00	8-13	78-08	14	290°	4-5		3	1	1		22	27
,,	1025	2½ ,,	8-13	78-08	8-13	78-04	14	,,	,,		2	4			5	11
,,	1300	3 ,,	8-13	78-04	8-13	78-06	14	,,	3-4		3				2	5
25-8-53	2005	3 ,,	7-58	77-42	7-58	77-52	15	,,	,,						4	4
26-8-53	0245	3 ,,	8-14	78-05	8-13	78-04	13	,,	,,		6	1	1		4	12
,,	0620	2 ,,	8-13	78-04	8-12	78-08	13-14	280°	,,		3		3	1	3	10
,,	0900	2½ ,,	8-12	78-08	8-12	78-09	14	,,	,,		5	2	4		3	14
,,	1225	3 ,,	8-12	78-09	8-12	78-04	14	,,	,,	1					4	5
,,	1630	2 ,,	8-12	78-04	8-14	78-05	14-13	,,	2-3		1	2	5		6	14
10-8-55	0945	2½ ,,	7-49	78-01	7-51	77-49	24-23			5	2		4	2	1	14
29-8-55	1230	3 ,,	7-51	77-41	7-51	77-44	22			3	14			20	1	45

Appendix II

Data from ‘ Braconglen ’

Voy. No.	Station No.	From		To		Date	Time	Depth Fm.	Reds	Greys	Blacks	Leather jackets and Cats	Shark and Skate	Small	Pomfret	Prawns	Total	Remarks
		Lat.N.	Long. E.	Lat. N.	Long. E.													
43	49	8-13	78-00	8-13	78-00	2-9-53	0930 1200	14- 14	—	1	—	2	10	4	2	2	21	Prawns, Sharks & smalls.
43	50	8-13	78-00	8-13	78-05	,,	1230 1530	14- 14	—	1	1	4	10	6	1	5	28	Very strong S.W. Wind.
76	1	8-05	78-17	8-03	78-07	23-6-55	830 1130	24- 20	2	2	1	3	13	—	—	8	33	Mixed prawns, Pulini, Sharks; greenish white water.
77	2	8-03	78-07	8-00	79-55	7-7-55	1330 1630	20- 20	4	2	1	1	8	12	—	10	37	Small fish prawns, some skates; very heavy swell.
80	1	8-06	77-59	8-06	77-59	17-9-55	0515 0915	25- 19	—	—	—	7	7	4	—	2	20	

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PRAWN FISHERIES OF INDIA

by

N. K. Panikkar* and M. K. Menon**

The Prawn Fisheries of India rank, from the point of view of production, second only to those of the United States of America (F.A.O. Fisheries Statistics, 1950 to 1953[1]). A number of more or less detailed accounts concerning them have been published (Rai, 1933; Panikkar 1937; Chopra 1939 & 1943 and Naidu 1939). The species of edible crustaceans inhabiting the seas, brackish waters (backwaters), lakes and rivers of India are numerous and practically all of them, excepting the smaller crabs, contribute considerably to subsistence fishing. Those commonly known as prawns (shrimps) are commercially the most important among them, forming as much as 90 per cent of the total landings. In certain areas, especially on the West Coast, the catches of prawns as a group may be more than those of any other single group of fishes. One of such areas is the south-western extremity, comprising the State of Travancore-Cochin and an equally important area is the Bombay Coast, where prawn landings have shown substantial increases in recent years. The statistics of production of prawns from the different sectors of the Indian Coast will help to form an idea of the important position which they occupy in the coastal fisheries. These are given in Tables I to VIII which are self-explanatory.

Fishing Grounds :

Based on the environment in which the prawns are found, it may be convenient to recognize three categories of prawn fisheries, namely, marine fisheries, estuarine and backwater fisheries and freshwater fisheries.

The known fishing grounds in the open sea are seldom situated far away from the shore. Usually fishermen restrict their operations to the shallow areas within the 10-fathom line. During the monsoon months of June to August on the Malabar Coast shoals approach the shore so close as to make it possible for fishermen to use the cast net for catching them. Fishermen of the Bombay Coast do not, as a rule, go beyond 10-12 miles off the home ports, and if large towns are situated within a short distance from such ports, the fishery gains in impor
since the fishermen are able to get better retu

The Gulf of Kutch area is also an imp
prawn fishing centre.

The rich prawn fisheries of estuaries and
waters or saline lakes both along the east and
coasts of the country are probably more impo
from the point of view of present output tha
marine fisheries. Detailed statistics for thes
however, not available. The brackish natu
the water and abundance of food material i
form of animal and plant detritus provide extre
favourable conditions for the growth of y
prawns, immense numbers of which migrate
such areas every year. The long chain of
commonly called backwaters extending along
coast of Travancore-Cochin and South Ma
and the mouths of numerous hill streams in
Malabar and South Kanara Districts yield
quantities of prawns annually. The En
Pulicat, Collair and Chilka Lakes on the east
and the Gangetic Delta are also similar p
fishing areas. Of these the Chilka area is prob
the most important in production, but the
areas are potentially important, although often
fully exploited at present.

Various species of fresh water prawns are fi
from rivers and other bodies of fresh water thro
out the country. Some of them are caught
the brackish-water lakes also in certain mo
when the salinity is low, since the prawns mi
into them temporarily, chiefly for breeding (K
1915).

Species caught :

The marine prawns fished along the Indian c
are chiefly members of the Penaeidea. C
families of Decapoda Natantia do not occu
large concentrations and there is no comme
fishery of sea prawns based on families other
the Penaeid group. The most important comme
species are *Penaeus carinatus*, *P. indicus*, *Metapen*

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* Fisheries Development Advisor, Govt. of India, New Delhi, India.

** Central Marine Fisheries Research Sub-Station, Thevara Rd., Ernakulam, Kerala, S. India.

[1] In 1953 the shrimp production of U.S.A. was 107,000 metric tons, and of Japan 73,400 tons, while the av
annual production of marine prawns in India for the past five years is 94,713 metric tons (Vide Table I).

os, *M. affinis*, *M. dobsoni*, *M. brevicornis* and *eopsis stylifera*.

rinatus is the largest, reaching a length of and is brightly coloured. In most places, r, it is not caught in such large numbers as the

idicus grows to about 9″. This and its nce, practically along the entire coastline, probably the most important commercial

e 4 species of *Metapenaeus*, the first two grow t 5″, the other two are smaller. *M. dobsoni*, rather small, seldom growing over 4-4½″ h, is caught in enormous numbers, especially rackish water areas of the backwaters of core-Cochin and the Pulicat and Ennore

evicornis is the commonest penaeid of Bengal, imbers of which are caught from paddy fields ow lying areas.

benaeopsis stylifera, fished in large numbers he south-west coast during the warmer of the year is peculiar, since it does not into brackish water as the other species.

ng non-penaeid prawns species of Leander, ly *L. styliferus*, contributes substantially catches in the Gangetic Delta and on the coast. In Bombay it forms a sea fishery it is an estuarine fishery in Bengal.

nps, seldom exceeding an inch in length, ng to various species of the genus, *Acetes*, occur in vast shoals along the coast in certain months. They are then caught along with other prawns and fish and are marketed when other crustaceans are rare. In the Mandapam area, it contributes to a summer fishery.

The species caught from estuaries and backwaters are the same, excepting *Parapenaeopsis stylifera*, which rarely occurs in such localities. One important characteristic of the catches from these areas deserves to be emphasized, namely, that the vast majority of the prawns are young and immature, the fully grown mature ones being caught only from the sea.

The prawns caught from fresh water are species of *Palaemon*. They occur practically all over the country. Among them *P. carcinus* is the largest, fully grown specimens reaching about a foot in length. It is caught in appreciable numbers from the backwaters of Travancore-Cochin during the months of September, October and November. *P. idae* is similarly common in these waters from September to December. Several species of *Palaemon* along with penaeids form a very important fishery in the Collair Lake (in Andhra State) on the East Coast of India. It is a characteristic feature of such coastal lakes that they have a predominant *Palaemon* fishery during the rainy season when the water is fresh or nearly fresh, with Penaeids increasing in numbers during the following months when the salinity rises. Later, in the summer months the yield consists entirely of Penaeids. The species of importance in the Collair Lake are as follows :—

Prawns of Collair Lake

Species	*Remarks*
ndicus	Mainly salt water species found in Upputeru and further down
carinatus	Mainly in salt water—occasionally in fresh water regions of the lake
ueus monoceros	In fresh and salt water
carcinus	Mainly fresh water species tolerating brackish water
malcolmsoni	Do. do.
scabriculus	Only in fresh water
rudis	Occasionally in brackish water

nilar distribution of species is also found in and Chilka Lakes and other smaller coastal the East Coast of India.

Methods :

boat seine is one of the commonest types of d for commercial prawn fishing in the sea oth the south-west and south-east coasts. Fishermen seldom go beyond a depth of about 10 fathoms. The net may vary to some extent from region to region in respect of minor details ; but it usually has a bag-like part and a couple of wings projecting forwards. Two canoes of the dugout type with about 8-10 men are engaged in operating it on the south-west coast. On the east coast catamarans replace canoes. Besides prawns, various species of small fish are also usually caught by the same gear.

Another type very extensively used in estuaries and backwaters, creeks and shallow inlets of the sea etc. is a conical net with floats above and weights to anchor it or supported on pairs of stakes driven into the mud. Its size is variable, some of the largest in use along the coast of Bombay being 500-700 ft. in length with a mouth of 200-300 ft. in circumference. They are usually set against the tide, which sweeps the prawns into them, and are hauled up at the turn of the tide. Fishing with such stake nets is carried on throughout the year in the backwaters of Travancore-Cochin, wherever the tides are not too feeble.

Several variants of this method are in existence in different parts of India, but it may be emphasized that even small operating units give good yields and revenue to the State. For example, stake nets are a common feature of canal systems near the coasts. In the canals intersecting the Vypeen Island in Travancore-Cochin (Narakkal is a village in the island), the net is fixed at the end of two bamboo fences converging towards the middle from either bank of the canal. The right of prawn fishing in these canals is yearly auctioned by the Department of Fisheries of the State. The two main canals in Narakkal village, Bandar, and Appangad Canals which are auctioned together, are, according to the Department's estimate, expected to give an annual yield of about 110 cwts. of processed prawns (dry meat). The fishing rights are auctioned; the amounts realized in the auctions during the last three years are given below :—

1952-53	Rs. 12,000
1953-54	11,300
1954-55	9,100

The Chinese Dip nets, which are so conspicuous along the shores of the chain of lakes in Travancore-Cochin, also catch considerable amounts of prawns, particularly from the backwaters, practically all the year round (Panikkar, 1937).

The cast net, the drag net, a variety of wall net etc., are some other types of nets commonly used in various parts of the country to capture prawns.

The extensive paddy fields adjoining the backwaters and canals of the northern part of Travancore-Cochin form rich prawn fishing grounds, with an annual production at a modest estimate of about 4,000 tons of prawns. The estimate is based on the figures collected by the Central Marine Fisheries Research Station. The method adopted and data relating to various aspects of the fishery were given in the paper read at the last meeting of the Council (Menon, 1954). The high degree of efficiency reached in this type of fishery can be realized by the a yield per acre per annum which frequently ex a thousand pounds.

Mention may also be made of certain inge devices employed in some regions. In the Lake the Oriya fishermen construct long fen about 50′ in length, with a ring of traps at the end of each in shallow water about 3′ deep. habit of the prawns moving along the shore at is taken advantage of in this method. The guides them into the enclosure and thence the traps themselves at day-break.

In the shallow stretches of the brackish lakes of Travancore-Cochin and connected two canoes connected by two short bamboo (fore and aft) with a heavy iron chain fasten its two ends to the bows of the canoes are When the canoes are poled along, the chain over the mud at the bottom, scaring the pr They jump out of the water and almost alway into the canoes where they are trapped. Gop (1953) has given a detailed description of it rec under the name 'prawn junkhar or pachil' an pointed out that it is similar in principle to the 'seriat' of the Malay Archipelago and Burma to the 'Rua Kread' of Thailand.

Craft :

The craft used are generally the same a commonly used for fishing in each area.

Seasonal Variations :

Though a few prawns may be caught throu the year at various points along the coast, the m fishery is largely seasonal. On the west coas season generally coincides with the monsoon pe June to September, so far as the southern regi concerned. In other months, particularly October to April, few fishermen go for prawns small species of fish, since they find it more profi to go for sardines and mackerel, these months f ing the season for their fisheries. Investiga conducted at the West Hill Sub-Station of Central Marine Fisheries Research Station, shown that prawns are not absent in the co waters, though they may not be quite so abun as in the other months.

August to October are the best months in Bombay area and July to September, exten in places to December, the season in Sauras The season starts soon after the North East mon on the east coast and may last till about April in the Collair Lake, it extends from Ma December.

The backwaters of Travancore-Cochin pro an exception to this, since the stake nets and Chi ch appreciable quantities of prawns through- year although the peak of the fishery is in ths October or November to April.

ement and Regulation :

nly regulation now in existence is in respect addy field fishery which is allowed to operate out the middle of November to the middle l. This is done not so much in the interest ishery as in that of rice cultivation.

methods of fishing now in vogue do not the destruction on any appreciable scale of ry and leave sufficient numbers of breeding to replenish the stock. The fear of deple- not therefore arisen anywhere and thus no problem in management, requiring regulation fishery, has confronted the Governments of ous States.

chnology and Marketing :

ns which are intended for local consumption n to the markets as soon as possible after nded. Hawkers carrying baskets of prawns o) for door to door sale are a common sight oastal villages of Malabar and Travancore- Those intended for despatch in the fresh inland towns are packed between layers of r entire or after removing the chephalothorax. uantities of prawns are sent by rail packed rom Chilka Lake to the Calcutta markets. y increasing consignments of West Coast have been reaching the Madras markets. are also sent by rail to nearby towns from vay Stations adjoining the Collair and Pulicat The quantity of prawns consumed by n on the basis of subsistence operations to be fairly large in India.

ng.—During the last few years a small plant has been working at Cochin. Only are frozen at present. The capacity of the one ton per day and the time taken for the to be complete is about 24 hours. Prawns size weighing 30-35 to the pound are frozen after removal of cephalothorax, in blocks about 5 lbs. Smaller ones weighing upto e pound are also frozen after being boiled led. The chief market for the product is ed States of America. The present output order of 500 cases per month, each case g 50 lbs. Development plans of some of s include setting up of new Prawn Freezing

.—Several methods are in vogue for curing One of the simplest is spreading them out n for drying. They are then marketed as after they are shelled.

An improved method adopted extensively is to boil the prawns before drying. Boiling is done in metal containers (even kerosene oil tins in some places) with just enough water to cover them. Extra salt is sometimes added. After drying for 2-3 days they are put into gunny bags and 'threshed' with sticks or by beating the bags themselves on wooden blocks. The shell pieces are removed and the dry meat packed in bags mostly for export. The dried prawns thus made are of fairly good quality in the Cochin area. In some places, notably in the Kutch area, the curing is done in a very crude manner so that the final product happens to be very poor in quality and unattractive in appearance. Prawns processed in this manner have only a limited market in India, the bulk being exported to other countries.

Smoking of fresh prawns for about 4 hours is done in the Collair Lake area. The smoked product has not yet become popular with Indian consumers.

Semi-drying, a process popularized by the Madras State Fisheries Department, has certain advantages over the other methods, inasmuch as the product does not deteriorate even if kept for months, and when soaked again in water, tastes like fresh prawns (Naidu, 1939). In this method prawns are first boiled in 6% brine for about 2 minutes and then removed and shelled. They are then immersed in saturated salt solution for 15-30 minutes. Drying is done in the sun or by artificial driers, but the flesh is not allowed to become quite hard. An account of this process with recent developments is given by Venkataraman, Sreenivasan and Vasavan (1953).

Pickling of boiled and shelled prawns in vinegar or weak toddy with condiments and spices is carried on in Malabar as a cottage industry (Chacko, 1944). Home pickling of prawn is also popular in Malabar.

Marketing and Distribution.—It may generally be stated that marketing is seldom done by the fishermen themselves, except by a few who are fortunate enough to own their own fishing implements. Usually the catches pass into the hands of middlemen, to whom the former are bound to deliver the catches, because of prior commitments, and it is these men who usually undertake the responsibility of marketing.

In Saurashtra (Government Publication, 1953) a few merchants buy dried prawns wholesale from the fishermen, who would have taken advances from them, and are therefore bound to sell their products at fixed prices, usually quite low. These merchants are only agents of business interests in Bombay, who are well informed about the outside markets, and who are therefore in a position to make the maximum profit from the transaction.

In the Travancore-Cochin area a good portion of the catches of fishermen is bought by merchants who process them. The paddy field fishery is mostly in the hands of men who are able to invest the capital required for obtaining the land on lease and for meeting other initial expenses, very few fishermen being in a position to command it. They do the fishing and processing themselves by engaging hired labour when needed. The product is usually sold to wholesale dealers at Cochin, who export it to Burma and other eastern countries, where it finds a ready market. The price paid to the producers is never so low as in Saurashtra, but is generally in accordance with the prevailing market rates. It has varied from Rs. 500-1,000 per candy (a candy = approximately 6-1/3 cwts.) this year. Despite this, their margin of profit at present is not large, because of the high rents they are forced to pay to the land owners. The Department of Fisheries of the Madras Government has its own agency for distributing the semi-dried prawns processed under its auspices, to merchants and consumers. Exports of dried prawns* from Travancore-Cochin during the past three years are as follows :—

1952-53	3,991 tons
1953-54	5,322 tons
1954-55	4,368 tons

The approximate value of the 1954-55 exports would be of the order of Rs. 14,600,000. Owing to the cancellation of the Open General Licence for importing dried prawns into Burma there is a recent crisis in the industry, as large stocks have accumulated with the dried prawn merchants, who are therefore interested in developing new markets for this product.

III. Biology :

Much remains to be known of the biology of Indian prawns. The Prawn Research Unit of the Central Marine Fisheries Research Station has been mainly engaged in biological investigations relating to the penaeid species common along the south-west coast and has succeeded in collecting a considerable amount of data on several aspects. Along with these general investigations, more de studies were also undertaken on individual sp *M. dobsoni*, one of the most important sou species, was the first to be selected for such a and this work has been followed by work *stylifera* and *P. indicus* (Menon 1951, 195 1954).

Spawning and Maturation.—So far as is kn all species spawn only in the sea. *M. dobson* *P. stylifera* (Menon, 1951 and 1953) liberate eggs mostly in coastal waters not more than fathoms in depth. *P. indicus*, however, see prefer deeper water, its eggs or larvae having seldom obtained along with those of the fo The breeding period is fairly long and contin in regard to the two smaller species : Nove March (*M. dobsoni*) and October-Decembe *stylifera*). In the case of the larger specie *indicus* a certain amount of evidence has bee lected indicating the existence of two such pe October-November and May-June. Both o first two become mature in the first year of lif males of *M. dobsoni* maturing in backwaters

Early Life History.—The life history of *M. dobsoni* has been completely followed a agrees closely with those of other species, s of which have been studied by various scien Eggs hatch out in the form of nauplii, which u go three moults to pass into the Protozoea The latter again moults thrice before beco the Zoea or Mysis. The Mysis also sheds its the same number of times and becomes a post It gradually acquires most of the adult chara in a succession of moults, generally twelve in nu Compared to the larvae of *P. japonicus*, *M. mon* and *M. affinis* (Hudinaga 1942) the only no difference which the Indian species shows respect of the number of moults of the nau it being six in the Japanese species.

Growth and Longevity.—Rearing experi and statistical analysis of length measure (length frequency curves from month to m have made it possible to arrive at certain conclu regarding the growth of *M. dobsoni* during the three years of its life.

	First	*Second*	*Third*
Male	about 70 mm.	90-95 mm.	110 mm.
Female	,, 75-80 mm.	100-105 mm.	120 mm.

These figures also bring out the fact that growth rate of females is higher than that of males and that it becomes apparent even in the first year of life. The maximum size attained by the two sexes c quently shows some difference.

Length frequency studies carried out in re

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* Dried prawns with shells constitute about 33% of the fresh weight and shelled dried prawns constitute 16% fresh weight.

lifera have led to the inference that this rows in the course of a year to 90-100 mm. . Evidence is also available which tend that after maturity females grow faster les.

ata presented above indicate that *M. dobsoni* about 3 years. It is not possible at present definitely if the maximum length of life is years. What can be safely concluded is ng the course of our observations extending years, the catches, both commercial and ntal, did not contain prawns that were bly older. Similarly *P. stylifera* has been live for 2 years. Data collected so far ermit of definite conclusions in regard to r species. Srivatsa (1953) is inclined that the life span of prawns of the Gulf of from 12-14 months and that they probably spawning.

naeid prawns studied here, with the excep- *. stylifera*, migrate into estuaries and back- uite early in life in the post-larval phase. proportion of the post-larvae of *M. dobsoni* *dicus* collected from such localities measured 6 mm. and 10 mm. respectively. Immense of such fry pass into these brackish water nost continuously throughout the breeding s evidenced by the collections made by from the Main Canal of Narakkal. They some months in such environments and back into the sea, where further growth nment of sexual maturity take place. The migration seems to be largely a passive ince they are usually carried by the large rainwater flowing into the sea during the period.

d Habitat.—It is now well-known that the rawns consists of the detritus, both animal , that accumulate at the bottom of their nd that they prefer areas with a muddy Along with this detritus they naturally ge quantities of sand and mud. Examina- stomach contents of numerous individuals led the presence of plenty of diatoms, ly when they are abundant in the plankton. *dobsoni* and *P. indicus* seem to consume ntities of algal matter when available, some omachs examined having been practically *P. stylifera* is apparently an exception to since, excepting diatoms, plant matter noticed in the stomach contents. Small eatures like Molluscs and worms, etc. he bottom may also be taken in.

anks.—On the South West Coast of India centrations of Penaeid prawns are usually the mud banks of the Malabar Coast. d banks are a characteristic feature of this coast and is probably the result of intense churning of the sea bottom during the heavy South West Monsoon, resulting in fine silt being suspended in definite patches along the coast and this is also probably connected with certain special geological features which are not yet fully understood. There is usually a heavy accumulation of nutrients (Phosphates and nitrates) in the mud banks (Seshappa, 1953). Prawn fishermen of the Travancore-Cochin Coast are well aware that in the *Chakara* or the mud banks the prawns are found in large numbers and they invariably carry out fishing operations in the placid waters of the banks.

Physiology of Prawns.—From the physiological point of view the prawns belonging to the families Palaemonidae and Penaidae are of great interest. The marine Palaemonids of Europe, i.e. *Leander serratus* (Common Prawn) and *Leander squilla* and the brackish water *Palaemonetes varians* are hypotonic to their surroundings when in sea water attaining isotonicity only in sea water of salinities 25, 25 and 22 parts per mille respectively (Panikkar 1940 & 1941). This behaviour is unusual for marine invertebrates and is associated only with certain groups of Crustacea in the coastal environment. It is not found in the Pandalidae or other true marine families of prawns. The Penaeid prawns on the Indian Coast have an osmotic behaviour similar to marine Palaemonids and the hypoosmotic regulation is associated with powers of regulating the chloride content of the blood when the prawns are in media of different salinities (Panikkar & Visawanathan, 1947). Recent work on ionic regulation has confirmed these findings on Palaemonids (Parry 1955). The ability of the Indian marine Penaeid prawns to migrate easily into coastal lakes and estuaries is correlated with their homoiosmotic behaviour and forms, like *Leander styliferus* at Bombay, have a habitat similar to *Leander serratus* in Europe, while it is mainly an estuarine prawn in the Gangetic Delta. The higher salt content in the blood of freshwater Palaemonids as compared with other freshwater invertebrates enables them to migrate more easily to brackish water even up to salinities not tolerated by several true freshwater species. Among the Penaeids the species most tolerant to changes in salinity is *Metapenaeus monoceros* which occurs in sea water, brackish water and in water that is nearly fresh. Even this species is not known to breed in brackish water, although this species or a close relative is known to breed in such waters in Australia.

Both in Penaeids and Palaemonids the sexually mature forms are less resistant to salinity changes than the juveniles. The migratory movements are probably connected also with the optimal salinity requirements of sexually mature prawns and of egg-bearing females in the case of Palaemonids.

Taxonomy

Order	*Decapoda*
Sub-order	*Natantia*
Tribe	*Penaeidea*

Family : 1. *Penaeidae :* Last 2 pairs of legs well developed—gills many.

Sub-family : *Penaeinae.* Exopodites on all maxillipeds and usually some legs. Arthrobranchs in double series. A leaflike appendage on inner side of 1st antenna.

Genera :

I. Rostrum serrated on both edges ; a pleurobranch on the last thoracic somite (14) ; exopodites on all or all but the last pair of legs.
   1. First pair of Chelipeds short and slender in both sexes .. *Penaeus*

II. Rostrum serrated on its dorsal edge only.
   1. A pleurobranch on somite 13, but not on somite 14.
      i. Exopodites on all or all but the last pair of thoracic legs .. *Metapenaeus*
   2. No pleurobranchs on somites 13 × 14. All the thoracic legs with expodites.
      i. Epipodites absent from at least the last 3 pairs of thoracic legs *Parapenaeopsis*

Species :

Penaeus *P. carinatus ; P. indicus*

Metapenaeus *M. monoceros; M. affinis; M. dobsoni ; M. brevicornis*

Parapenaeopsis *P. stylifera*

Family 2. *Sergestidae :* Last one or two pairs of legs reduced or lost. Gills few or wanting.

Sub-family : *Sergestinae.* Head not greatly *elongated*—Gills present.

Genus : *Acetes*

(From Alcock, 1906)

(Vide also Key for Identification, Appendix)

Future Prospects of Prawn Fisheries of India :

In connection with the future development of the prawn fisheries of India, problems relating to the improvement or modernisation of methods of catching, processing and marketing should first claim our attention. These are indeed common problems concerning Indian Fisheries in general. The possibility of effecting improvements in the present catches of prawns and ways and means of achieving it are briefly discussed hereunder, particula
the light of the facts brought out by the investig
of the Prawn Research Unit.

The bulk of the catches from the sea and p
cally the entire catch from other environ
consist of young and immature prawns. T
especially true of the larger species like *P. car*
P. indicus and *M. affinis.* It is now known tha
prawns pass into comparatively deeper regi
the sea, and since the marine fishery is at p
confined almost exclusively to the shallow c
waters usually not exceeding 10 fathoms in
such prawns would naturally escape being ca
The rise of the Shrimp fishery in Central and
America and the information on the habits
Penaeids of the Gulf of Mexico give every rea
think that there are large unexploited stocks of
prawns in the Arabian Sea. Each species ma
its own pattern of vertical distribution as sho
Hildebrand (1954) for the Gulf of Mexico.
therefore, very necessary to undertake explo
fishing, trawling preferably, up to a depth of
fathoms, in order to discover if exploitable co
trations of prawns exist at such depths alon
coasts. Such shoals, when discovered, may
to be judiciously exploited for commercial pur
for the reason that most of the prawns wou
mature and therefore potential breeders, a
their stock is depleted by excessive fishing i
place, where there is a flourishing and
lucrative backwater fishery as in Travancore-C
the effect on the latter may be harmful sinc
annual recruitment of fry to the stock in such
may be considerably reduced.

Another possible line in which efforts at de
ment may be directed is prawn farming. Th
been pointed out formerly (Panikkar 1952)
prawn farming is already practised in some cou
of East Asia. Rao (1949) has remarked that
rough computation there are approximately
square miles of 'culturable' but at present
waters, lying scattered along the entire coa
of India in the form of tidal estuaries, back
and swamps. If even a portion of this vast
could be put to use for prawn farming, the
production is likely to be augmented substan
The availability of prawn fry in abundance i
neighbourhood and the possibility of allowing
to flow in and out by tidal action are the two
that would naturally determine the suitabili
any such areas for prawn farming. In an e
ment conducted by the Unit at Narakkal it has
shown that a minimum of 800 lbs of prawns co
harvested annually from every acre (Menon
If fish is also cultured in the off-season another
350 lbs of fish can also be caught. The total an
compares very favourably with the yield from

est tambaks in East Java, where six test
oduced in 1940-41, 330, 380, 470, 830, 230
lbs of prawns per acre, besides a normal
hanos (Schuster 1952). In the Philippines
of fish pond produces on the average about
315 lbs per acre per annum) of marketable
Penaeus monodon) of about 10" in length
id and Villaluz, 1950). The experiment
has yielded quite promising results which
arrant its repetition on an extended scale.

ossibility of expanding the rice-field fishery
rly situated land both in and outside the
seems well worth investigating.

mmes of Research and Development.—The
evelopment plans of the States and Central
ents in India include exploitation of off-
wn fisheries on an extended scale by the
odern shrimp trawlers and seines and some
e already been made in certain parts of
Corresponding with this increase in fishing
s, it is also proposed substantially to aug-
research programmes dealing with prawns
he conservational aspect of this valuable
source is fully borne in mind while the
cilities are expanded.

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APPENDIX

In the accompanying Tables (I to VIII), the landings of prawns and crustaceans during the years 1950-54 have been given. The figures are based on sample surveys conducted by the Central Marine Fisheries Research Station. For the purpose of Fisheries Survey, the entire coastline of India has been divided into 12 more or less homogeneous zones which represent the following areas.

Zone 1. West Bengal and Orissa.

Zone 2. Andhra Coast, from south of Gopalpur to north of Visakhapatnam.

Zone 3. Andhra Coast, from Visakhapatnam to Masulipatnam.

Zone 4. Andhra Coast, from south of M patnam to North of Pulicat Lak

Zone 5. Coromandel Coast, from Pulicat L Cuddalore.

Zone 6. Coromandel Coast, from sout Cuddalore to Devipatnam.

Zone 7. Palk Bay & Gulf of Mannar, from of Devipatnam to north of Comorin.

Zone 8. Travancore, Cochin and South Ma from Cape Comorin to Ponnani

Zone 9. Malabar and South Kanara, from of Ponnani River to Mangalor

Zone 10. Kanara and Konkan Coast, from of Mangalore to South of Rat

Zone 11. Bombay and Gujarat, from Ratnag Broach.

Zone 12. Kathiawar Coast.

	(Figures in tons. 1 ton = 2,240 lb.)					Average for 5 years
	1950	1951	1952	1953	1954	
Total catch of marine fish	570,860	525,482	520,002	572,278	578,966	553,518
Total catch of prawns and other crustaceans	73,694	75,584	75,785	89,254	151,789	93,221
Percentage of prawns and other crustaceans to the total catch ..	12.91	14.38	14.57	15.60	26.22	16.84

Note :—The other crustaceans included in the above figures form only a negligible fraction of the total prawns and crustacean catch. These figures also do not include prawns caught in brackish water and fresh water.

Table I(a)

Zone wise production of Marine Prawns & Crustaceans

Zones	(Landings in tons)					Average for 5 years
	1950	1951	1952	1953	1954	
1	168	47	148	70	545	196
2	589	334	448	339	169	376
3	6,660	4,575	3,867	5,283	234	4,124
4	65	65	65	65	2,036	459
5	—	382	419	1,539	960	660
6	—	—	10	157	151	64
7	—	—	12	—	7	4
8	958	3,751	5,254	740	3,144	2,769
9	7,334	7,252	3,656	1,868	3,394	4,701
10	362	1922	891	329	177	736
11	57,558	57,256	61,015	76,550	140,972	78,670
12	—	—	—	2,314	—	463
Total ..	73,694	75,584	75,785	89,254	151,789	93,221

Note :—Kathiawar areas have been included in the table only where sample survey figures have been available. Total production of prawns in Saurashtra according to published official reports average about 4,000 tons per annum.

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Table II

Landings of Prawns & Crustaceans—1950 (*in tons*)

Zones	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	—	—	117.98	—	10.74	0.82	0.29	2.96	5.01	1.39	14.00	14.81	168
2	—	119.96	43.51	9.39	110.23	125.66	66.92	53.44	34.88	13.76	11.23	—	589
3	538.13	955.24	1673.53	541.89	343.21	282.06 (19.66)	601.41 (40.70)	707.15	237.32 (5.52)	130.65	356.14	222.54	6589 (71)
4	2.89	—	—	—	1.88	5.43	17.47	5.87	4.84	9.81	16.83	—	65
5	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—
7	—	—	—	—	—	—	—	—	—	—	—	—	—
8	753.85	—	—	—	—	43.09	—	4.54	—	—	— (15.46)	141.02	943 (15)
9	1235.77	324.50	154.25	148.81 (0.53)	125.72 (7.50)	3218.20 (17.23)	13.29	46.11	—	317.56	1197.13	527.44	7309 (25)
10	0.38 (27.73)	— (140.81)	— (15.23)	0.54 (10.47)	9.46	12.38 (7.71)	5.98 (5.18)	11.95 (1.51)	111.46	1.23	—	—	153 (209)
11	3259.92	4177.70	7498.98	9907.78	13001.82	—	—	—	—	5166.38	5450.76	9094.50	57558
Total	5818.67	5718.21	9503.48	10619.41	13610.56	3732.24	751.24	833.53	399.03	5645.59	7061.55	10000.31	73694

Note I.—Fig. within brackets are the landings of crustaceans, which form 0.43% of the total prawns and crustacean catch of 1950.
Note II.—The sign "—" indicates nil catch.

Table III

Landings of Prawns & Crustaceans—1951 (*in tons*)

Zones	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	0.50	16.57	6.26	0.34	5.80	0.80	2.66	2.11	2.40	1.93	3.50	4.13	47
2	—	—	51.95	17.70	2.89	18.58	30.02	148.83	34.84	24.51	1.92	2.76	334
3	102.40 (3.91)	121.44	357.15	26.75 (78.14)	263.91 (0.74)	378.18 (7.56)	280.52 (274.80)	276.70 (228.27)	511.95 (181.00)	220.97 (112.63)	229.47 (204.74)	463.22 (250.13)	3233 (1342)
4													65
5	10.06	28.27	—	—	44.74 (26.09)	3.56 (1.90)	—	—	128.39	122.61	—	16.37	354
6	—	—	—	—	—	—	—	—	—	—	—	—	—
7	—	—	—	—	—	—	—	—	—	—	—	—	—
8	—	19.75 (46.50)	222.40 (49.01)	465.87	761.37	60.41	421.37	1234.75 (416.47)	—	—	53.02	—	3239 (512)
9	—	75.32 (84.00)	239.46	204.68	973.93	1602.31	1811.69	2170.37	90.23	—	—	—	7168 (84)
10	5.29 (26.88)	17.92 (154.99)	— (145.81)	175.09 (208.59)	1.43 (15.34)	—	19.11 (22.73)	973.91 (0.67)	23.25 (20.09)	— (24.98)	— (37.51)	— (48.39)	1216 (706)
11	11884.70	5221.34	5897.17	6202.33	13137.87	—	—	—	2370.08	976.70	1168.49	10396.97	57256
12	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	12033.74	5786.10	6969.21	7379.49	15234.11	2073.30	2862.90	5452.08	3362.23	1484.33	1698.65	11181.97	75584

Note I.—Fig. within brackets indicate landings of crustaceans, which form about 3.54% cf the total prawns and crustacean catch of 1951.
Note II.—The sign "—" indicates nil catch, and the gaps denote no data available.
Note III.—The estimate for Zone 4 is the estimate of 1950.

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Table IV

Landings of Prawns & Crustaceans—1952 (*in tons*)

Zones	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	12.42	4.82	—		5.39 (0.07)	2.46	9.48	27.09	14.41	3.96	32.01	35.94	148
2	6.19	4.64	10.33	15.16	30.28	56.89	109.65	77.53	39.48	90.03	7.82	—	448
3	170.17 (238.25)	85.19 (403.44)	177.09 (162.44)	356.78 (59.78)	191.34 (7.48)	117.00 (36.50)	107.03 (119.96)	175.18 (104.00)	101.36 (53.74)	121.04	169.45 (420.39)	77.37 (412.02)	1849 (2018)
4													65
5	18.07	—	—	—	4.23	36.66	42.60 (1.56)	72.61 (0.14)	85.67 (1.30)	36.39	62.29	57.48	416 (3)
6	0.85	—	—	—	—	—	9.15	—	—	—	—	—	10
7	—				1.96	0.45 (0.08)	2.89 (0.04)	1.48 (0.33)	4.77	—	—	—	12
8	—	—	22.44	8.82 (243.67)	478.64	—	103.80	733.91	223.26 (3372.33)	67.13	—	—	1638 (3616)
9	—	273.49	569.48	494.02	378.17	100.66	531.06	363.31	172.40	22.78	338.21	412.42	3656
10	(23.42)	(298.04)	(11.54)	(117.04)	(128.28)		145.16 (20.63)	125.84 (21.05)	—	—	—	—	271 (620)
11	9406.19	2664.96	9533.80	8775.91	18435.32	—	—	—	387.78	2587.38	4623.63	4600.03	61015
12	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	9875.56	3734.58	10487.12	10071.18	19661.16	350.70	1203.01	1702.47	4456.50	2928.71	5653.80	5595.26	75785

Note I.—Figures within brackets indicate landings of crustaceans which form about 8.26% of the total prawns & crustacean catch of 1952.
Note II.—The sign "—" indicates nil catch, and the gaps denote no data available.
Note III.—The estimate for zone 4 is the estimate of 1950.

Table V

Landings of Prawns & Crustaceans—1953 (*in tons*)

Zones	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	—	—	41.60	—	—	—	0.99	6.82	5.46	13.73	1.40	—	70
2	—	62.72	3.35	—	24.24	33.11	87.58	52.22	52.63 (2.00)	20.79	0.36	—	337 (2)
3	70.04 (410.64)												5283
4													65
5	139.52	316.07	86.05	151.36 (56.00)	98.11	132.72	221.15	229.61	63.11	6.98	17.75	20.57	1483 (56)
6	—	—	100.23	—	13.16	41.93	1.68	—	—	—	—	—	157
7	—	—	—	—	—	—	—	—	—	—	—	—	
8	—	—	—	—	—	—	—	307.02	399.98 (28.36)	(4.64)	—	—	707 (33)
9	—	616.60	228.67 (4.72)	13.01 (5.46)	44.46 (5.03)	84.62 (0.79)	101.25	259.32	172.00	1.65	218.57	111.85	1852 (16)
10	(6.01)	(23.32)	(19.69)	0.21 (3.85)	1.58 (39.41)		2.91 (0.39)	95.60	117.66 (1.28)	0.04 (17.05)	—	—	218 (111)
11	11235.48	11474.73	4401.42	8747.88	13548.23	1229.87	—	—	4298.71	2642.44	7173.89	11797.35	76550
12													2314
Total	11861.69	12493.44	4885.73	8977.77	13774.22	1523.04	415.75	950.59	5141.19	2707.32	7411.97	11929.77	89254

Note I.—Figures within brackets indicate landings of crustaceans, which form about 0.24% of the total prawns & crustacean catch.
Note II.—The sign "—" means nil catch; the gaps denote no data available.
Note III.—The estimate of zone 4 is that of 1950.

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TABLE VI

Landings of Prawns & Crustaceans—1954 *(in tons)*

Zones	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	—	—	—	—	—	0.72	4.97	3.43	5.30	0.49	93.80	436.28	545
2	12.96	1.52 (0.13)	2.69	0.52	7.12	18.83	31.64	17.93	13.66	42.83	8.68	10.51	169
3									19.51	—	57.87	—	234
4									—	49.00	—	17.86	2036
5	52.76	76.84	65.64 (1.93)	57.78 (0.87)	57.55 (6.89)	122.44 (11.41)	196.30	155.88	84.87	30.06	23.03	14.71 (1.00)	938 (22)
6	—	—	93.97	4.18	—	—	—	—	—	6.15	1.28	45.42	151
7	—	—	—	—	—	—	—	—	—	—	7.00	—	7
8	10.06 (5.30)	— (17.12)	32.01 (5.77)	58.56 (5.97)	61.94	20.93	213.11	2414.71	190.59	25.25	71.19	11.36	3110 (34)
9	93.23	68.45	120.76 (1.55)	77.37 (3.61)	66.63 (3.57)	307.86	2428.21	141.05	—	5.53	14.83	61.24	3385 (9)
10	— (1.60)	0.17 (0.41)	— (1.12)	0.05 (28.24)	10.83 (63.49)	5.34 (18.80)	12.59 (5.40)	18.04 (2.97)	— (2.20)	0.13 (3.89)	— (1.70)	—	47 (130)
11	4293.99	5727.66	6327.68	34637.69	46281.40	—	—	15.51	597.84	24086.04	12978.28	6026.30	140972
12	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	4469.90	5892.30	6653.12	34874.84	46559.42	506.33	2892.22	2769.52	913.97	24249.37	13257.66	6624.68	151789

Note I.—Figures within brackets denote the landings of crustaceans which form about 0.13% of the total landings of marine prawns and crustaceans in India.

Note II.—The sign "—" indicates 'nil' catch, and the gaps denote no data available.

Note III.—The total estimates of zones 3 and 4 are based on last 4 months' observations.

Table VII

1953—*Landings of Prawns and other shell-fish (lbs) at important centres.*

Centres	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Gopalpur	Nil	Nil	—	—	Nil	Nil	122	959	6033	876	90	Nil
Lawson's Bay	Nil	9824	558 (P)	Nil	3983 (P) 1317 (S)	4666 (P) 2233 (S)	9600 (P) 8617 (S)	6273 (P) 5720 (S)	9752	3061 (P)	36 (P)	Nil
Kakinada	3034 (S) 626 (P)	—	—	—	—	—	—	—	—	—	—	—
Triplicane	4404 (M) 1487 (A)	9389 (M) 218 (A)	3364 (M) 343 (A)	4820 (A) 2674 (M) 292	2990 (M) 2431 (A)	3180 (M) 725 (A)	4031 (M)	4308 (M) 667 (A)	2079 (M)	337 (M)	858 (M) 523 (A)	1083 (A) 281 (M)
Adirampatnam	Nil	Nil	11657 (P)	Nil	1051 (P)	2761 (P)	Nil	Nil	Nil	Nil	Nil	Nil
Tuticorin	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Vizhingam	Nil	Nil	Nil	Nil	Nil	Nil	Nil	29519 (P)	35583 (P) 1473 (A)	Nil	Nil	Nil
Calicut	Nil	56892 (M) 2728 (P)	21429 (M) 899 (P) 702 (Pp)	1266 (Pp.) 984 (M) 164 (P)	4109 (P) 2643 (M)	4399 (M)	6846 (M) 3315 (Pp.)	35136 (M) 691 (Pp.)	30232 (S & Pr.)	202 (M)	26954 (Pp.) 657 (A)	13108 (M) 360 (Pp.)
Karwar	Nil	Nil	Nil	7 (P) 1 (M)	27 (P) 4 (M)	—	178 (P)	3702 (P) 24 (M)	6707 (P)	1 (P)	Nil	Nil
Versova	1305963 759178 (S)	1712343 (S & Pr.)	625675 (S & Pr.)	1323021 (S & Pr.)	2105893 (S & Pr.)	174559 (S & Pr.)	Nil	Nil	767199 (S & Pr.)	318402 (S & Pr.)	1463439 (S & Pr.)	1479722 (S & Pr.)

Explanations to Abbreviations :
— No data collected or available
M. *Metapenaeus* spp.
P. *Penaeus* spp.
A. *Acetes* spp.

S. Shrimps.
Pr. Prawns.
Pp. *Parapenaeopsis.*
Where no symbols are placed after a figure, it indicates that the total catch is comprised of prawns, shrimps and other crustaceans.

Table VIII

1954—*Landings of Prawns and other Shell-fish (lbs) at important centres*

Centres	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Gopalpur ..	Nil	Nil	Nil	Nil	Nil	70 (M) 20 (P)	463 (M) 214 (P)	535	461 (Pr. & Cr.)	33 (Pr. & L)	Nil	Nil
Lawson's Bay ..	1961 (P)	253 (P)	473 (P)	104 (P)	1033(M) 621 (P)	4169	7007	4383	1213 (P) 616 (M)	652 (P) 128 (M)	197 (P) 134 (S)	Nil
Kakinada ..	—	—	—	—	—	—	—	—	599 (M) 102 (S)	Nil	1150 (M) 920 (P)	Nil
Triplicane ..	1905 (M) 215 (A)	2796 (M) 212 (A)	1730 (M) 964 (A)	2005 (M) 828 (A)	1945 (M) 1092 (A)	2876 (M) 571 (A)	3412 (M)	3226 (M)	2254 (M)	2694 (M) 241 (A)	1829 (M) 901 (A) 159 (Cr.)	1747 (M) 114 (Cr.)
Adiram-patnam ..	Nil	Nil	6197 (P)	582 (P)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Tuticorin ..	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Vizhingam ..	Nil	Nil	Nil	Nil	Nil	3702 (P)	9771 (A) 4476 (P)	211792 (P) 40532 (A)	2850 (Ct.)	Nil	Nil	Nil
Narakkal ..	1093	Nil	3239	7264	6653	4426	8273	7543	Nil	Nil	14397 (Pr.)	Nil
Calicut ..	5876 (M) 4114 (Pp. 1240 (P)	3274 (P) 2966 (Pp.) 412 (M)	8115 (P) 2310 (Pp.) 1815 (M)	13132 (Pp.) 1342 (P)	8866 (Pp.) 983 (M) 346 (P)	12701 (M) 3053 (Pp.) 364 (P)	238353 (M) 5738 (P) 1047 (Pp.)	15523 (M) 3750 (P) 316 (Pp.)	Nil	1335 (P)	3623 (Pp.)	13289 (M) 1221 (Pp.)
Karwar ..	Nil	25 (P)	Nil	2 (P)	222 (M) 4 (P)	345 (P)	785 (P)	751 (P)	285 (Cr.)	262 (Cr.) 17 (P) 197 (Ll.)	Nil	13 (Cr.)
Versova ..	929327	1008978	1061440	6181206	8488109	Nil	Nil	2598	48025 (Pr.)	824480(Pr.)	3011504 (Pr.) 76349 (S)	774193 (Pr.) 227966 (S)
Veraval ..	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Explanation to Abbreviations :

— No data collected or available.	Pr. Prawns	Cr. Crabs.	P. *Penaeus.*	M. *Metapenaeus* S. Shrimps.
A. *Acetes*	Ct. Cuttlefish	Pp. *Parapenaeopsis.*		Ll. *Loligo.*

Where no symbols are placed after the figures, it indicates that the total catch is comprised of prawns, shrimps and other crustaceans.

4

IDENTIFICATION OF MARINE AND INSHORE PRAWNS OF COMMERCIAL VALUE IN INDIA

by

M. K. Menon*

Key is intended only for the provisional tion in the field of the more important ial species of prawns in India. Species e comparatively rare and therefore do not te materially to the prawn fishery have not luded in it, inasmuch as the purpose for has been prepared is to enable those engaged y survey work to gain some idea of the species comprising the catches in different the vast coastline of the country and at parts of the year. The colouration is eneral guide and should not too rigidly be on.

al for the Key has been drawn principally taxonomic work of Alcock, Kemp and other but the characters have been tested against s of prawns taken from different centres of

or the identification of species of *Palaemon* *nder* have been omitted, as those of the re mainly fresh-water in habitat and those tter have commercial importance in very s.

Key to families

tennules with 2 flagella. maxilliped 1 with no external lobe on exopodite; walking legs 1-3 chelate; pleura of abdominal somite-2 do not overlap those of 1 and 3 .. *Penaeidae*

tennules with 3 flagella; maxilliped 1 with an external lobe at base of exopodite; walking legs 1 & 2 chelate; pleura of abdominal somite 2 overlap those of 1 and 3 .. *Palaemonidae*

Key to genera

idae.

andibular palp present; hepatic spine usually present; branchiostegal spine absent .. *Palaemon*

ndibular palp present; hepatic spine absent; branchiostegal spine usually present .. *Leander*

strum with teeth on both dorsal and ventral margins .. *Penaeus*

B. Rostrum with teeth only on dorsal margin .. *Metapenaeus* & *Parapenaeopsis*

B1. Exopodites on all but the last pair of thoracic legs; a pleurobranch on somite 13 but not on 14 .. *Metapenaeus*

B2. Petaloid exopodites on all thoracic legs; no pleurobranchs on somites 13 and 14 .. *Parapenaeopsis*

Key to species

Penaeus :

I. Telson with 3 spinules in the distal half of each border; carapace with 3 median longitudinal dorsal grooves, one of which is excavated in the postrostral crest; all extending nearly up to its posterior border; rostrum slightly double curved with 9 dorsal and 1 ventral tooth; maximum size about 7″ .. *P. canaliculatus*

II. Telson without marginal spinules; the median dorsal grooves, if defined, never reach to the posterior border of the carapace:

1. Exopodite of last thoracic legs absent or quite vestigial; rostrum has a distinct double curve with 8 teeth on its dorsal and 3 on its ventral margin; a longitudinal post-antennal sub-hepatic crest near the antero-lateral angle of carapace; body dark, the general colour varying from olive green to deep bluish grey with dark transverse bars on abdomen; outer surface of peduncle of pleopods bright lemon yellow; maximum size 10-12″ .. *P. carinatus*

2. Exopodites of last thoracic legs well developed though small:

    i. Rostrum nearly straight with 6-8, usually 7 dorsal and 3 ventral teeth; an oblique post-antennal sub-hepatic crest near the antero-lateral angle of carapace; upper (outer) antennular flagellum considerably shorter than its peduncle; maximum size about 9″ .. *P. monodon*

    ii. Rostrum has a double curve, with 8-10 dorsal and 4-6 ventral teeth; it has a moderately elevated dorsal crest in both sexes; no sub-hepatic crest on carapace; upper antennular flagellum a good deal

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Central Marine Fisheries Research Sub-station, Ernakulam, Kerala, S. India.

longer (1½ times) than its peduncle; body translucent white with numerous small brown and green chromatophores; appendages pink turning to crimson in mature specimens; maximum size about 8″ .. *P. indicus*

(*a*) Rostral crest conspicuously high and of a broadly triangular form in both sexes; dactylus of maxilliped 3 of adult male hardly half the length of propodite .. *P. indicus* var. *merguiensis*

(*b*) Rostral crest high, but not forming a decided triangle; dactylus of maxilliped 3 of male 1½-2¾ times length of propodite .. *P. indicus* var. *penicillatus*

Metapenaeus

I. Rostrum in adults reaches nearly to or beyond the tip of the antennular peduncle:—

i. Rostrum has 9-12 dorsal teeth; a strong simple spine on the basis of all 3 pairs of chelipeds; last pair of thoracic legs seldom reach to tip (usually reach a little beyond middle) of antennal scale; in adult male proximal end of merus of last leg notched, bounded anteriorly by a large hook-like spine and posteriorly by a lobule of the ischium; beyond spine edge of merus is finely denticulate; body densely tomentose, semitransparent with close-set dot-like red and brown chromatophores; maximum size 6½ inches. .. *M. monoceros*

ii. Rostrum more curved than in M. monoceros and usually has 9 or less than 9 teeth; last pair of thoracic legs usually surpass (sometimes by a dactylus length) the tip of the antennal scale; in male no lobule on ischium; notch of merus is bounded by a twisted tooth and not by hook-like spine; edge of merus without denticulations; upper part of body usually pale bluish green; lateral portions and appendages orange or red; maximum size 6½ inches. .. *M. affinis*

iii. Rostrum has a well marked double curve, a well developed basal crest with 7-9 teeth; last pair of thoracic legs fall considerably short of the middle of the antennal scale and often in the female are merely horn-capped stumps; in male there may be a second tooth on the merus beyond the notch; no denticulations; the spine on the basis of 3rd cheliped in the same sex is comparatively larger and roughly lancet-shaped; semitransparent with numerous red or
brown and green chromatophores;
mum size 4½″. .. *M. dobsoni*

II. Rostrum just extends beyond the eyes
7 teeth and a higher crest than in *M. dobson*
pair of thoracic legs reach more than a da
length beyond the tip of the antennal scale; in
a small tooth on its merus; no denticula
maximum size 5″. .. *M. brevicornis*

Parapenaeopsis

I. Epipodites on 2nd maxillipeds and firs
pairs of chelipeds; the usual isolated epig
tooth of the rostral carina present.

1. (*a*) Outer antennular flagellum as lo
carapace (without rostrum); sub-h
ridge defining the anterior part
cervical groove is continued to t
of the branchiostegal tooth; tels
1-3 strong lateral marginal spin
pointed tip; rostrum with a
double curve, projecting b
antennular peduncle, bearing
teeth proximally, the distal p
being styliform; latter part of
greenish brown, sides and appe
are scarlet; maximum size 4½″.
.. *P. stylifera*

(*b*) Telson with only a single pair of
or occasionally a minute 2nd pair
.. *P. stylifera*
coromandelic

2. The sub-hepatic ridge does not run
the branchiostegal tooth; only
does the telson have an obscure
marginal spine:

i. Outer antennular flagellum as long
peduncle; rostrum shorter, not rea
tip of antennular peduncle; ofte
adult male the styliform part is
maximum size 5½″ .. *P. sculptilis*

ii. Antennular flagella shorter than
peduncle:

(*a*) Post rostral carina continued t
posterior border of the cara

(*a*) Rostrum without styliform p
reaching only to middle of 2nd
of antennular peduncle in
sexes; antennular flagella sh
than peduncle; post-rostral
canaliculate; spine on basis of
pair of chelipeds indistinguish
.. *P. uncta*

(*b*) Post-rostral carina sharp; spin
basis of 2nd pair of chelipeds
strong; in females there is a
spine on the basis of the 3rd
of chelipeds .. *P. maxillipe*

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5

PENAEID PRAWN FISHERIES OF AUSTRALIA WITH SPECIAL REFERENCE TO NEW SOUTH WALES

by

A. A. Racek*

ustralian waters, a considerable number of cially important penaeid prawn species ndant in the estuarine (inside) area, and in e inner and outer littoral areas down to the the continental shelf. Here, as in other f the world (with the possible exception of however, the prawning activities were confined e midforties to the estuarine area. Follow- incidental discovery of prawn schools in aters off New South Wales in 1947 a steadily ng number of offshore trawlers began to on these new grounds. With the develop- the offshore prawn fisheries, particularly in n Bight near Newcastle, N.S.W., and on in the Ballina-Evans Head area on the far ast of the same State, special prawn investiga- re initiated in 1951 by the Fisheries Branch, ecretary's Department, in response to ex- concern about a possible depletion of the stocks. Since May 1953, comprehensive iled studies were carried out by the author biology, ecology, and embryology of the nportant commercial species in New South nd in adjoining Queensland waters. Their ary results, which helped to clear quite a of previously encountered problems, are discussed in this paper. A revision of the glected taxonomy of Australian Penaeinae, occurring in commercial catches, has been sewhere (Racek 1955).

recently, the Western Australian State s in conjunction with the C.S.I.R.O., of Fisheries were exploring previously offshore grounds along the whole western of Australia, and observations were carried the Department of Harbours and Marine n stocks in the vicinity of Moreton Bay, nd.

E AUSTRALIAN PENAEID PRAWN FISHERIES

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storical evidence is available, as to where n commercial fishermen began with prawning activities in Australia. It seems most likely, however, that migrants from Mediterranean countries, particularly Italy and Greece, were the first to explore the estuaries in and around Sydney for the presence of these delicious crustaceans, which were known to them from their homelands. Whitelegge (1889) and Ogilby (1893) were referring to a considerable prawn production in the last two decades of the previous century. The inside prawn fisheries appear to have grown rapidly since and became the means of livelihood of a large number of fishermen in New South Wales. An incidental discovery of schools of offshore prawns in 1946 and 1947 led to the expansion of trawling activities in ocean waters off New South Wales. Large quantities of adult penaeid prawns were at first trawled in Stockton Bight, and almost simultaneously new and promising grounds were discovered off Evans Head. Since then many other payable grounds were found, and the total production of the combined offshore fisheries in New South Wales began to surpass the estuarine production considerably. At present, estuarine and offshore prawns are commercially captured in New South Wales along the whole coastline, from Tweed Heads in the north to Twofold Bay in the south.

The abundance of large penaeid prawns in Queensland waters, and particularly the success of prawning activities in offshore waters of New South Wales, led soon to the expansion of the offshore prawn fisheries into adjoining Queensland waters. Although some estuarine prawn fisheries (Brisbane River, Mary River) have been existing for a long time in Queensland, their expansion is due to extensive trawling activities in Moreton Bay. More recently, new and well-stocked grounds were discovered off Sandy Cape near Bundaberg, where large tropical species are abundant. Preliminary biological investigations, carried out in the area inside the Great Barrier Reef, indicated the presence of suitable grounds, and it is to be expected that trawling activities will soon expand to these tropical waters.

Prawn trawling in offshore waters is still in an experimental stage in Western Australia and in

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* Marine Biologist, Fisheries Branch, Chief Secretary's Department, Sydney, N.S.W., Australia.

South Australia, although penaeid prawns are captured in estuarine waters of these States, as well as occasionally in Victoria.

Fishing grounds

At present, penaeid prawns are commercially captured in Australian waters on two different habitats, each possessing a stock distinct in many features from that of the other.

The inside prawn fisheries are operating in an area, comprising the lower tidal parts of rivers down to their entrance, coastal lakes and lagoons (landlocked or open), and brackish pools possessing various sea connections. These waters range from salt to slightly brackish and show enormous variations due to the influence of seasons, floods, land drainage and even wind. This environment is strongly influenced by sudden changes of salinity and temperature. Bottoms are mostly muddy with plenty of detritus, occasionally sandy with patches of weed, or with dead and living oyster shells. Depths vary from 0 to 5 fathoms.

Offshore prawn trawlers in Australia are operating at present only in a part of the inner littoral area. This extends from the surf or river entrances to a variable distance (in New South Wales between 2 and 5 miles offshore), influenced more or less by the boundary of the main ocean currents, in which prawns seem to be absent in commercial quantities. The water generally has a fairly high salinity, but less than oceanic density, particularly in perifluvial areas. During river floods this area is usually turbid with plenty of suspended matter. This environment is less influenced by sudden changes of salinity and temperature, but strongly so by wind against the current, and by ocean swell. Bottoms are mostly a mixture of mud and sand, with an occasional growth of kelp. Depths vary from 1 to 25 fathoms.

The exploration of new far offshore grounds in the outer littoral area with experimental otter trawls and baited traps is discussed in the Section on Biological Investigations. These grounds have not yet been commercially exploited.

Fishing methods, gear and vessels

In the estuaries of Australia, penaeid prawns are captured chiefly with pocketed scoop nets, hauling nets, set pocket nets, cast nets and modified otter trawl nets. In ocean waters large otter trawl nets, measuring up to 20 fathoms from wingtip to wingtip, are used solely by professional fishermen.

Hauling nets and cast nets are mainly employed in the comparatively still and shallow coastal lakes and lagoons, pocketed scoop nets and set pocket nets in inlets and channels with a considerable current during the outrunning tide, and otter nets in some restricted tidal rivers.

(*a*) *Hauling net :* Hauling nets are of va lengths, according to the locality in which the used, and range from 5 to 75 fathoms in total le In New South Wales the compulsory mini mesh size for these nets (and all other type 1¼ in. Various methods are employed in hauling nets. They are worked either by fisher wading along the shore or by boats. The di ion of the hauls may be parallel to the shore an angle to the latter. In still waters a dete school of prawns is herded by this method tow the shore or towards one end of the net, whi being lifted finally with the catch onto the shor into a boat. Another method of hauling is so called ‘ running prawns ’, used in estuaries slight tidal currents. A motor launch is anchor a certain distance from the shore, and a rowing proceeding from this launch, pays out the full le of the net towards the shore, at an angle to the la At the end of the setting operation one end of hauling net is fastened to the launch, the othe a tree or a pole on the shore. The outrun tide drives the school of prawns against the which leads them, due to being set at an a towards the shore. From time to time the fis man in the rowing boat, moving along the cork towards the launch, lifts up the leadline in a c nuous operation and works (or ‘ runs ’) the ama prawns finally to the anchored launch, where catch is hauled in.

(*b*) *Cast net :* The capture of prawns with cast net is a quite ingenious method, altho the results are limited due to the comparati small size of the net. It is circular in outline, hauling rope is attached to the centre, the lea is the circumference of the net. Its use dema considerable skill. The net is skilfully folded pa over the left forearm, partly held by the right h and the hauling line is prearranged on the grou The net is then thrown with a swinging movem which causes the weighted circumference to sp so that the net hits the water fully extended. A hitting the surface the leadline sinks down fast, thus encircling all swimming animals f immediately below the net to the bottom. The of cast nets is illegal in New South Wales, altho in other States, particularly in Queensland, i often employed by commercial and amateur fis men in shallow coastal waters.

(*c*) *Pocketed scoop nets :* These modified sc nets with a moderately long and narrow po (or bag) are employed by professional fishermen in localities with considerable current during outgoing tide, where other means of capture ets) are restricted with the view to the tion of the local prawn fishery. The quite catching capacity of these nets warrants a ry commercial catch only during the (last to first quarter of the moon phase), aturing prawns migrate to their offshore grounds in dense schools.

t pocket nets : In New South Wales, set ets are restricted to a few inlets and estuaries, ither other methods are impracticable, additional channels for the egress of sea- . These nets are of various lengths and vith one to several pockets or bags. The nets cross channels or inlets during the outgoing 'dark' nights. The outrunning prawn forced by the more or less strong current he net, are guided by the 'wings' into the vhich are lifted and emptied from time to fishermen in rowboats, anchored above ets.

ter trawl nets : The design of the otter Australia is equivalent to that of other and its detailed description appears to fluous. It is used by professional fisher- some restricted estuaries (small boards, 6 ets) but it is the only method employed by lian professional fishermen in ocean waters. g to the size of the vessel and its power unit, very large otter boards are used, and the sure at the average 12 fathoms, ranging o 20 fathoms. The minimum legal mesh ew South Wales is 1¼ in., which in offshore vl nets, however, is used only in the cod- e average offshore nets measure 2 in. ngs, 1½ in. in the bunt, and 1¼ in. in the To prevent unnecessary culling of under- ns and fish, many offshore fishermen in th Wales already adopted voluntarily a sh size, using 1¾ in. in the bunt and 1½ in. od-end. Large mesh blubber traps are in blubber-infested waters, although some use a more 'baggy' net and a throttl- n the cod-end, to be operated from the otter boards. The average depths for rawling in the inner littoral area are 12-20 the average trawling time (net on bottom) minutes. The nets are operated with s on power winches.

ing vessels : In New South Wales there esent 2,223 territorial and 169 extraterri- s engaged in the fishing industry. Terri- s are restricted in their activities from the to the 3 mile offshore limit, extraterri- ts are operating in deeper waters beyond Many of these boats, however, are not lly engaged in prawning but in general fishing and trapping as well. In the estuaries, the length of the boats range from 12 to 30 feet, the size of the offshore trawlers varies from 18 to 75 feet. The smaller estuarine boats are equipped with petrol engines. The majority of larger boats, and particularly the offshore trawlers are powered by diesel engines ranging from 35 to 140 b.h.p. Power winches on trawlers are operated partly by transmission from the main power unit, partly by auxiliary engines. A few large boats are equipped with electric refrigerators and cooking facilities to warrant proper handling of the catch during peak productions. Most of the trawlers and other boats, however, employ crushed ice in their holds to preserve the catch. They cook their catch ashore after returning to their port.

Catch statistics

In New South Wales the combined prawn fisheries (estuarine and offshore) rank third amongst individual fisheries by the volume of production. They are preceded only by the production of mullet (Mugilidae) and flathead (Platycephalidae). The fluctuations of catches in this State are shown in Fig. 1, showing separate values for the estuarine, offshore and total production since 1937-38. The statistical data were collected for financial years, i.e., for a period from July 1st to June 30th. The fall of the production in 1951-52 appears to be due to an extremely dry summer and autumn period, a fact which shows its consequences even a season later in the absence of young prawns in estuarine waters. The following sharp rise of catches in ocean waters, however, is not only caused by favourable climatic conditions, but is also due to the exploration of additional offshore grounds and an increased number of operating trawlers.

Seasonal variations

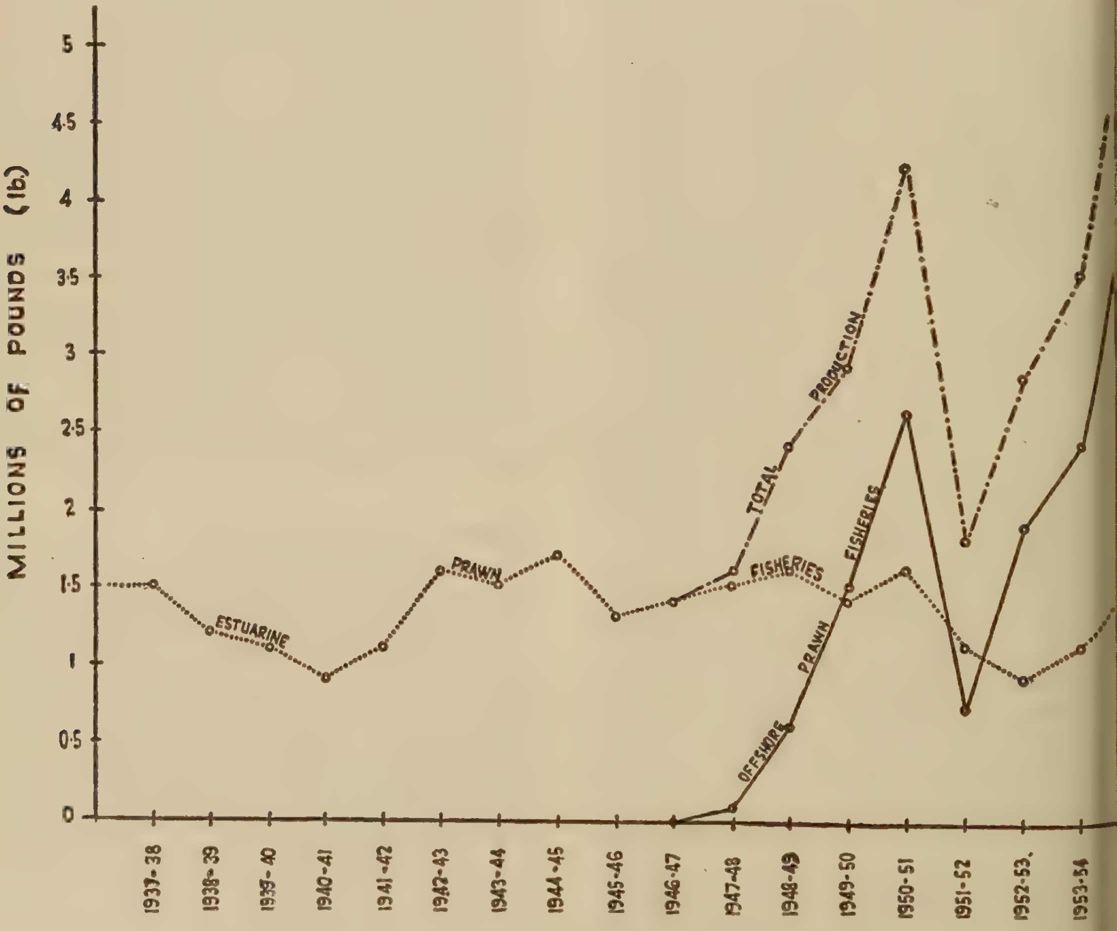
Under normal weather conditions, penaeid prawns in New South Wales usually enter the commercial catch in estuarine waters during the latter half of November, and are abundant until at least the first half of March. Under the same climatic conditions offshore commercial species usually commence to appear in schools around the first half of January and are taken in quantities until the end of June. As most of the Australian commercial species possess a strictly perifluvial habitat, their appearance and abundance is strongly influenced by climatic conditions and the resulting amount of land drainage. Thus their abundance in dry to very dry seasons is quite scarce, at least on the known trawling grounds. In such unfavourable seasons they may appear later in the year and disappear earlier. In wet to very wet summers when heavy rainfalls cause extensive river floods, commercial species may be present in quantities on known grounds almost throughout the year. Thus the years 1954 and 1955 were extremely wet with repeated heavy river floods, and penaeid prawns were present in commercial quantities along the northern half of New South Wales even through the southern winter months. However, final statistical data for this period are not yet available.

The estuarine prawn fishery in New South Wales, producing mature stages of one strictly estuarine species (*Metapenaeus mastersii*) and adolescent or immature stages of a number of offshore species, usually commences the commercial catch ahead of the offshore fishery. Between February and June, however, the offshore fishery shows peak productions of mature or at least maturing commercial species, and stays well ahead of the inside fishery for the rest of the season.

Management and regulations

With the expansion of the prawn fisher
Australia, particularly in New South Wales
the turn of this century, certain restriction
regulations appeared to be necessary in view
conservation of the available stocks. These r
tions, particularly those concerning the est
fishery, vary considerably on different loc
Aiming to protect the available prawn stocks th
chiefly as follows :

(1) Minimum legal size of prawns.
(2) Minimum legal size of mesh.
(3) Maximum legal length of nets.
(4) Restriction of certain fishing metho
gear).
(5) Closure during daylight in some est
(6) Total closure of certain parts of est



Fluctuations in prawn catches in New South Wales ew South Wales the minimum legal size n (uncooked) prawns is 3½ in. Queensland raised the legal size from 2⅔ to 3 in. Size ere originally introduced at a time, when were taken solely in estuarine waters. As prawns were then believed to be immature, duction of a legal size limit was meant as a e measure. However, as different penaeid showing enormous differences in adult engths, are not discriminated in the cial catch, only some smaller species are thus otected. The major part of offshore species heir return to their deep-sea spawning is completely immature even far above the d legal length.

inimum legal size of mesh for all types of New South Wales is 1¼ in. Together with ns of the length of nets, this regulation to be far more important for the conserva- he prawn fisheries, as well as a means of limination of undersize commercial fish prawn catch. It is strictly enforced by rtment. As many fishermen have already to larger than legal mesh size with the view quality and larger size of the prawns, search and tests concerning the efficiency nets may show the necessity of a slightly mesh size.

e of the otter trawl in ocean waters is not , apart from the limitations of the mesh wever, trawling activities in most of New ales' estuaries are banned, and where they tted (Clarence R., Hunter R., Hawkesbury ackson) the length of the net is limited to . Set pocket nets are permitted only in le areas (Myall R., Wallis Lake) where n one channel allow the free egress of life e netting operations.

al closure in the Tuggerah Lakes, banning ercial capture of prawns during daylight came imposed following cases of food caused by improper handling of the catch ak productions in the mid-forties.

more, parts of almost all estuaries in New les are permanently closed with the view nservation of the fisheries generally.

of the fisheries

portance of the Australian prawn fisheries characterized by the considerable upward he production in New South Wales, as Queensland. Penaeid prawns are available rcial quantities during the late summer- nn period generally from the 36th parallel , although their abundance and the dura- eir occurrence are gradually increasing towards the tropics. In offshore waters their commercial catch at present seems to be strongly influenced and limited by the necessary nearness of a local market, thus causing the extensive exploitation of some few and limited grounds, mainly along the northern half of New South Wales and southern Queensland. Although the preliminary results of the current prawn investigations do not indicate a depletion of the available stocks, such limited and intensively worked grounds could be seriously affected as far as overfishing is concerned. In view of the short life cycle of the great majority of commercial penaeids, such a possible serious reduction of the supply on limited grounds would be difficult to overcome. Furthermore, as such a possible reduction would affect consistent prawn species first, these species may become replaced by migratory (inconsistent) species, gradually displacing the former stock. An already visible decline in the offshore production of king prawns (*Penaeus plebejus*), a very consistent species, in favour of the inconsistent school prawn (*Metapenaeus macleayi*) may be an indication of the progress of such a development on some favoured grounds in New South Wales.

To prevent such possible difficulties, prawn fishermen should be encouraged to explore and exploit new grounds. Equipped with adequate refrigeration, trawlers will be able to work even on well-stocked grounds along the sparsely inhabited tropical coasts of Australia, where trawling activities are unknown due to transport difficulties. During the course of detailed prawn investigations in New South Wales a number of new, well-stocked grounds were found in this State and are being worked since. In Queensland, after the exploration of rich offshore grounds near Bundaberg, and increasing number of trawlers moved from Moreton Bay into this new area. Since commercial species have been found to be abundant on suitable grounds inside the Great Barrier Reef, trawling activities may be extending shortly also into these tropical waters.

HANDLING AND PREPARATION OF PRAWNS

In spite of the rich abundance of prawns in Australian waters and the comparatively high production in relation to the number of operating boats, an export market for these crustaceans does not yet exist. Due to a local preference for 'whole' prawns, the total catch is sent to the markets with heads on, either in raw condition (green prawns) or more frequently cooked. In view of the highly perishable nature of the prawn 'heads', particularly in the warm climate associated with this fishery, the proper and expedited handling and transportation of the catch is of utmost importance.

Handling and transportation

After emptying the cod-end on the deck of offshore trawlers, the prawns are culled and sorted and the marketable catch is then placed in cane baskets, where it is thoroughly washed with a hose. The prawns are then transferred to wooden boxes between layers of crushed ice and placed in the holds. A few large trawlers are equipped with refrigerators, the rest carry ice in the holds. After the holds are fully loaded, the trawlers usually return to their ports in the vicinity of the trawling grounds to transfer their catch to the cooking plants. During seasons with peak production, some larger trawlers along the far north coast of New South Wales cook their catch on board to ensure its reaching the markets or storage plants in good condition. Large tanks, heated with diesel oil, are equipped with wide rims of wire netting to prevent the spilling of the catch in rough seas. Their capacity for one operation varies from 50 to 150 lbs. After the catch is properly cooked (10-15 minutes) the prawns are removed from the tank, transferred to baskets or perforated metal trays and cooled down with a hose. The catch is then, after complete cooling, transferred to wooden boxes between layers of ice (or without ice on refrigerated boats), which are placed in the holds.

The majority of trawlers can absorb catches from 800 to 2,000 lb without endangering the edible quality of the prawns. Usually they stay offshore for 12-15 hours. Where a greater number of trawlers operate from the same port, radio messages are flashed to the cooking plants from the trawling grounds, reporting the individual catch per boat. The cooking plants are thus able to arrange for additional manpower and equipment, if necessary.

Most of the prawn boats operating in inside areas employ somewhat simpler methods in handling, chiefly due to the smaller size of the fishing vessels and to the limited grounds. Estuarine fishermen usually transfer their sorted catch to baskets or directly into their small holds without any icing and return to shore after being fully loaded. The catch is lifted here from the boat in baskets, washed by submerging the baskets in water, cooked in mostly improvised large tanks on the shore, cooled, salted, and packed in wooden boxes between layers of ice for transportation to the market. Such smaller craft usually return again to their fishing grounds after landing their catch, repeating such operations as often as required.

Cooking and freezing

Some larger cooking plants at the main centres of the prawning industry along the north coast of New South Wales are designed to absorb and process large quantities of prawns. In the majorit
are run by fishermen's co-operatives, althoug
others are privately owned by fishermen
landed catch is freed of ice, weighed, cooke
super-heated steam, cooled in running water,
in wooden boxes, salted and finally transfe
cold storage.

A modern snap-freezing unit has been r
installed in the cooking plant of the Balli
operative. The prawns are there snap-fro
4 lb blocks, seven of these making a carton
blocks are kept in cold storage (or during tra
tation in refrigerated trucks to distant m
at a constant temperature of 0°F. The
of the processed prawns, when thawed afte
storage, is equal to fresh cooked prawns a
flavour is completely retained.

On account of the absence of an export mark
the local preference of fresh cooked prawns
is at present no canning industry in Au
although various canning experiments hav
carried out in this country. At some places
ever, drying or ' chowing ' of prawns is carr
by proprietors of Chinese restaurants.

Distribution

The marketing of prawns in New South
is governed by the Fisheries and Oyster
Act 1935-1949. All prawns for human con
tion must be brought to and sold in the
The various co-operatives transport the iced
by rail or road to the markets in the
populated cities on the east coast where the d
is high. At present (March 1955) the
price for 1 lb of cooked prawns is £A–2/2
fishermen), £A–3/4 (in the market), and £
(for the public). However, the prices vary
with the seasons and abundance of prawns.

Interstate consignments are delivered fro
South Wales to Melbourne and Brisbane
in special refrigerated trucks.

BIOLOGICAL INVESTIGATIONS

The biology of Australian penaeids, al
being commented on for individual spec
various Australian writers (Dakin 1935, 193
1946 ; Dakin and Colefax 1940 ; Morris and
1951), has never been before the subject of
prehensive study concerning all species of ec
importance. The present investigations,
out since May 1953 chiefly in areas with the
prawn productions, were aimed at solving
problems and phenomena connected wit
fishery. Their preliminary results are here
discussed.

occurring in Commercial Catches

species of the subfamily *Penaeinae* present ralian waters are shown in Table 1 (abun- ndicated with x):

mall size of some of these species (*P. novae-* *T. curvirostris*, and *T. anchoralis*) renders ommercially unimportant, although they pear during the season in large schools. hers again are too rare in Australian waters nt their capture in payable quantities.

The most important commercial species (in order of their importance) in New South Wales are *Metapenaeus macleayi*, *Penaeus plebejus*, *Metapenaeus mastersii*, *Metapenaeus incisipes*, *Penaeus esculentus*, and *Penaeus carinatus*.

The major species of Queensland's estuarine production are *Metapenaeus mastersii*, *Metapenaeus incisipes*, *Penaeus plebejus*, *Penaeus esculentus* and *Penaeus merguiensis*. In ocean waters of this State the production of *Penaeus merguiensis* occupies the leading place, with that of *Penaeus plebejus*, *Penaeus*

Species	N.S.W.	Qld.	W.A.	S.A.	Vic.
arinatus Dana ack) tiger prawn	x	x	x	—	—
aeruleus Stebbing prawn	rare	rare	—	—	—
misulcatus de Haan er prawn	rare	—	rare	—	—
sculentus Haswell (brown) tiger prawn	x	x	x	—	—
erguiensis De Man rawn	rare	x	x	—	—
dicus M. Edwards awn	rare	rare	—	—	—
tisulcatus Kishinouye ing prawn	rare	rare	x	x	—
ebejus Hess ng prawn	x	x	—	—	x
accullochi Schmitt ed king prawn	rare	rare	—	—	—
us macleayi (Haswell) wn	x	rare	—	—	x
us endeavouri (Schmitt) prawn	rare	x	x	—	—
us incisipes (Bate) reasy back prawn	x	x	?	—	—
us mastersii (Haswell) easy back prawn	x	x	x	—	?
sis sculptilis (Heller) rawn	—	x	?	—	—
(*Metapenaeopsis*) *ae* (Haswell)	x	x	x	x	?
us (*Trachysalambria*) (Stimpson)	x	x	x	—	—
us (*Trachypeneus*) Bate)	rare	x	x	—	—

Table 1. Species of Penaeinae in Australian waters

esculentus, *Penaeus carinatus*, and *Metapenaeus endeavouri* following.

Along Western Australia, *Penaeus merguiensis* and *Penaeus latisulcatus* may become species of economic importance.

The Australian distribution of *Penaeus latisulcatus* apparently ranges to South Australia, where this species seems to be the only one of commercial value.

The comparatively cold waters along Victoria appear to be inhabited by only a few east coast species of economic importance. Amongst them, *Metapenaeus macleayi* and *Penaeus plebejus* occur with certainty in payable quantities south of the N.S.W. border.

In view of a possible expansion of the Australian offshore prawn fisheries to new grounds, particularly in deeper waters of the continental shelf, the given order of commercial importance may undergo a change.

Distribution of species

As the distribution of penaeid prawns in Australian waters is strongly influenced by the seasonal system of ocean currents in the Indo-West pacific area, the ecological boundaries for the majority of Australian species are quite pronounced. The preliminary results of a survey of Australian prawns appear to allow of a more or less clear separation of the following 3 regions:

(1) *Eastern subtropical region*
Lakes Entrance (Vic.) to Cape Moreton (Qld.)

(2) *Tropical region*
Cape Moreton to Cape Inscription (W.A.)

(3) *Western subtropical region*
Cape Inscription to Kangaroo Island (S.A.)

The first region comprises the habitats of eastern subtropical species. Typical species in it are *Penaeus plebejus* and *Metapenaeus macleayi* in inner littoral waters.

The second ecological niche appears to be filled in the majority by strictly tropical commercial species, with the typical appearance of *Penaeus merguiensis*, *Penaeus esculentus*, *Penaeus carinatus*, *Metapenaeus endeavouri*, and *Parapeneopsis sculptilis*.

The third region is inhabited by western subtropical species with *Penaeus latisulcatus* as the typical form.

In eastern Australian waters there is a quite sharp boundary between the habitats of tropical and subtropical species situated at about latitude 28°S, although stray specimens of both groups may occur somewhat further south or north respectively. An equivalent north-south boundary on the western Australian coast has not yet been observed. However, according to surveyed material from Wes Australia, such a dividing line seems to be situ further north, most probably due to the influ of colder currents and, consequently, mean temp tures. The north-south boundaries are particu sharply defined for *Penaeus merguiensis*, *M penaeus endeavouri*, and *Parapeneopsis sculptili* tropical, and *Metapenaeus macleayi* as a subtro species.

The distribution of *Penaeus plebejus*, *P. escule* and *P. carinatus* appears to be less defined in eas coastal waters. *P. plebejus* is to be found northern Victoria to central Queensland, and *esculentus* as well as *P. carinatus* range to the ce coast of New South Wales. On the west c *P. latisulcatus* occurs even in tropical waters, b absent, however, along the main eastern coast as *P. plebejus* does not occur in the western re

Amongst commercial species, *Metapen mastersii* appears to be the only form with a circ Australian distribution, for it has been captu in both subtropical regions as well as in the tro Some not yet utilized smaller species, as *Tra peneus curvirostris* and *Penaeopsis novae-gui* also have a wide distribution around Aust *Trachypeneus anchoralis*, however, seems to limited to tropical waters and appears to be abundant in the west than in the east.

Habitats

The estuarine (inside) area in New South W is usually inhabited in summer months by matu to mature greasy back prawns (or greentails), gether with immature king prawns (*Penaeus pleb* and school prawns (*Metapenaeus macleayi*). greentail (*Metapenaeus mastersii*), an inside bree species, is usually present throughout the although its appearance is somewhat irreg King prawns and school prawns are tempor present in this area from postlarval stages in late autumn to adolescent stages of an average length of 3½ in. in mid-summer of the follo season, when they leave the inside area on spawning run to ocean waters. The school pra an early spawner, usually leaves the estuaries followed by the king prawn. Their spaw migrations take place usually during the outg tide at nights with decreasing moon phases.

The inner littoral area in New South Wale usually stocked with maturing to mature (or at impregnated) school prawns and with imma to maturing king prawns. The offshore gr back prawn (*Metapenaeus incisipes*) is very present in this area, as well as smaller specim of the common tiger prawn (*Penaeus esculentus*) the giant (or black) tiger prawn (*Penaeus carina* With the possible exception of the king pra

ecies is often found on sand, all other
efer mud bottoms, or at least a mixture of
d sand. Consequently, prawns appear to
t in commercial quantities on parts of the
reas, where the ocean currents are too
allow the presence of an undisturbed mud
The average body length of prawns in
is 4½ in.

ing and trawling experiments in deeper
f the outer littoral area revealed the pres-
quantities of king prawns, common tiger
and giant tiger prawns on mud bottom.
hese far offshore habitats in depths ranging
to 90 fathoms seem to represent the optimal
of both species of tiger prawns, and to a
xtent even that of the king prawns. The
jority of these prawns are females with
ture, and often spent ovaries. Species of
eus are absent in these depths. The
rawns on these grounds measure 13 in.
average body length is 8½ in.

ons

from the mentioned seaward spawning
olescent offshore prawns from the estuaries,
many other irregular movements of prawn
inside and ocean waters, chiefly due to
climatic or food conditions. Not all
ial species are affected by such migratory
its, and consistent and inconsistent forms
distinguished.

tent prawns prefer a certain habitat in a
ed area, which may be, however, very
reaching from the estuaries to the outer
rea. These species do not form pro-
age groups, except during their seasonal
run and are to be found, year by year, in
bundance on the same grounds. Due to
ce of migratory schooling habits, consis-
ns are rarely caught in considerable quan-
cept when leaving the estuaries. *Penaeus*
nd *P. esculentus* belong to this group.

Inconsistent prawn species are always on the move and show a preference to turbid waters and soft muddy grounds. They form pronounced age groups and dense schools and may occur in enormous quantities on inner littoral grounds, only to be found absent in the following season. Their abundance in perifluvial areas seems to be closely linked with the occurrence of river floods, and their presence on certain grounds is greatly influenced by the conditions of weather and sea. When the accumulation of silt, brought down by flooded rivers, ceases in ocean waters, they usually follow the current which moves this suspended matter along the coastline. Owing to their extensive schooling habits these species are often caught in great quantities. *Penaeus merguiensis* and *Metapenaeus macleayi* are typical inconsistent species in Australian waters.

The mass migration of prawns of all age groups from the estuaries to the ocean during extensive river flood is chiefly caused by the resulting rapid fall of the salinity in inside waters. On such occasions even large populations of *Metapenaeus mastersii* were found to leave the estuaries. This species usually prefers waters of low salinity and is rarely present in the inner littoral area. With the return of normal salinities in the inside area, however, these prawn stocks re-enter the estuaries during the ingoing tide in all but the adult stages.

Sex ratio, reproduction, spawning grounds

Male and female prawns do not occur in constant proportions on the fishing grounds, but may vary considerably from season to season from a slightly predominant male to an almost pure female population. Although the sex ratio varies with different commercial species, a certain mode is perceptible within the same species for certain grounds in given seasons.

The average sex ratio per cent observed in the extensive material collected for population studies in all 3 ecological areas during the period of spring 1953 till winter 1955 is shown in Table 2.

Locality and species	summer		autumn		winter		spring	
	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
area								
us mastersii	45	55	28	72	17	83	48	52
etapenaeus spp.	47	53	29	71	usually	absent	54	46
p.	59	41	18	82	23	77	37	63
oral area								
us spp.	30	70	21	79	36	64	49	51
p.	60	40	32	68	15	85	48	52
oral area								
p.	4	96	3	97	1	99	no data available	

m body length of prawns in consideration: ♂♂ 3 in.; ♀♀ 3½ in.)

Table 2. Percentage sex ratio of Australian prawns

The impregnation of females takes place after their ecdysis (casting of shell), which occurs chiefly during full moon phases. In view of the peculiar reproductive habits of penaeid prawns, direct evidence as to the location of their mating and spawning grounds is almost impossible to obtain. Indirect evidence, however, can be gathered by quantitative sampling and plankton survey.

The spawning grounds of *Metapenaeus macleayi* have been indirectly located in depths ranging from 25 to 35 fathoms, those of *Penaeus plebejus* between 50 and 55 fathoms. Extensive plankton collections carried out in surface and bottom runs with descending series of nets, tied to otter trawls in action, revealed concentrations of demersal penaeid eggs in about 30 fathoms average depths. The eggs were hatched in silk cages (in ocean waters) and in experimental tanks (in the field laboratory) and the larvae reared to post-larval stages, in which their identity (*Metapenaeus macleayi*) could be established. The eggs were collected in early summer on mud by the lowest plankton net, attached just above the otter boards.

Another concentration of sub-demersal penaeid eggs has been located further offshore in late summer above mud bottom in 55 fathoms by a plankton net fishing in about 40 fathoms. Hatching experiments with these eggs failed after the second protozoea stage and the identity of the material could not be established with certainty. The larvae, however, were identical with those described and figured by Dakin (1938, 1940) as *Penaeus plebejus*, but there is a possibility that they may belong to another species of *Penaeus*, perhaps *esculentus*.

As the collected eggs were in an early stage of development (blastula stage in *Metapenaeus*, nauplius stage in *Penaeus*) conclusions can be made as to the situation of the actual spawning grounds. Generally, *Metapenaeus* spp. seem to spawn closer onshore, *Metapenaeus mastersii* even in inside waters (Morris and Bennett 1951), whereas species of *Penaeus* appear to prefer greater depths further offshore. The sub-demersal property of the eggs, belonging to the latter genus, is most probably due to a higher salinity in the open ocean.

Routine plankton catches in ocean waters often prove the presence of post-larval stages of the genera *Penaeus* and *Metapenaeus* at great distances from the shore. It is therefore probable that only a portion of the penaeid larvae and post-larvae will ever reach the estuaries, whereas the rest may spend its whole life cycle at sea. The vulnerability of inside breeding species consequently appears to be greater than that of offshore spawners.

Observations in the outer littoral area

The present investigations established the o habitats of a number of commercial species. *penaeus mastersii* is to be found in all stages inc adults in the inside area and only rarely in the littoral area. *Metapenaeus macleayi* and *in* were found to prefer mudbanks in the sha parts of the inner littoral area in adult life, both species mate and spawn. *Penaeus plebej* though present in adolescent stages (up to in both the inside and inner littoral area, sh preference in adult life for sandy bottoms in g depths just beyond the outer border of the littoral area. In view of the complete abse a prawn fishery in deeper waters, however, was at first little evidence as to the optimal h of the tiger prawns (*Penaeus esculentus* and *P* *natus*), which were only occasionally taken o present prawning grounds.

In an effort to locate the presumable o habitats of these species, trapping experi were carried out in New South Wales in far of waters ranging from 50 to 90 fathoms. M funnel-type fish traps proved to be unsatisf and were replaced later by improved wing designs. The rectangular sides of a wooden 3 x 2 x 2 feet were covered with ½ in. bird wire One square side of this trap represented the door, the other carried an upward and inward wing of wire mesh, so that a 2 in. slit was left between the upper rim of the wing and the t the trap. The traps were fitted with spikes o bottom and were heavily weighted. Baited horse meat or liver, they were set in various d usually in sets of four. The experiments carried out from 12 to 22 miles offshore i Ballina, Port Macquarie, and Stockton Bight

Results were negative in waters with heavy currents, usually between 40 and 60 fathom the north coast of New South Wales. Tra experiments in 65 to 75 fathoms resulted in individual catches, the largest being 74 p weighing 52 lbs. The majority of these p were *Penaeus carinatus*, measuring from 7 to together with large (9 in.) *Penaeus esculentus*. prawns of an average body length of 8½ in. also present. Only fully mature females taken in these experiments.

The mentioned trapping experiments were from being a satisfactory fishing method, and loss of gear through rough seas, whales, and truction by ships was considerable. Since detection of these deep sea stocks of large com cial species, trawling experiments were carried in greater depths of the outer littoral area. of the north and central coasts of New South

hus examined with the view to the possibility
r offshore fishery. The results of these test
g activities were quite satisfactory and fair
ties of large to very large mature prawns
aken between 50 and 82 fathoms.

henomenon associated with these deep sea
for which an explanation has not yet been
is the almost complete absence of males.
varies of all females are ripe, some of them
igns of regeneration after at least 1 spawning.

ng and marking experiments

ous attempts have been made during the
investigations to stain or mark live prawns
er to trace their unpredictable movements.
ging and hole-punching methods appear to
racticable in view of the small size of prawns,
periments were focussed on suitable biological
Decisive factors in the choice of such dyes
) their efficiency, (2) the time of their visi-
and (3) their lethal properties. The follow-
es were tested in the course of the experi-

) Methylene Blue, (2) Trypan Blue, (3)
Red, (4) Nile Blue Sulphate.

he early stages of the experiments, the dyes
pplied by hypodermic needle. This method,
r, had to be abandoned because of high
ty. Later the technique of total immersion
ns in dyes was tested and proved to be satis-
. The dyes (1) to (3) were used as a 1%
of stain in seawater. In order to ascer-
e lethal properties of dyes, stained and non-
prawns were kept together under the same
nditions.

an Red proved lethal after an immersion of
han 3 minutes. Methylene Blue showed no
effects, however the dye disappeared com-
after 18 hours. Trypan Blue (immersion
minutes) was found to be an excellent stain,
h the mortality was more than 50%. Stained
were kept alive for more than 2 weeks and
a distinctive non-fading blue tint.

all the mentioned stains, however, Nile
lphate appears to warrant the most success-
ults. Used originally for studies of the
ons of starfish in the United States (Loo-
937), this stain is very effective and its lethal
ies are quite low. In the prawn staining
ents a 0.1% solution was used. 10 grams
Blue Sulphate were first dissolved in a small
of distilled water and then diluted in sea-
o make 10 litres of solution. The prawns
ed for 3-4 minutes in this dye bath, trans-
or 10 minutes into a well aerated washing tank and then released. The mortality during the dyeing process is low and does not exceed 20%. The retention of the stain by the prawns is considerable and covers a long period.

The practical use of this staining method in studies of the migrations of prawn populations is simple and efficient, although the retention of the stain may be limited with the next occurrence of an ecdysis.

WORKING KEY TO AUSTRALIAN SPECIES OF PRAWNS

1. Lower edge of rostrum with teeth .. 2
   Lower edge of rostrum without teeth .. 10
2. Lateral (adrostral) grooves extending almost to hind margin of carapace; lower edge of rostrum with 1 tooth; telson with 3 pairs of lateral spines 3
   Lateral (adrostral) grooves not exceeding hindmost rostral tooth; lower edge of rostrum with 3-5 teeth; telson unarmed 5
3. An accessory (secondary) pair of adrostral grooves on the sides of the upper blade not exceeding hindmost rostral tooth; post-ocular crest with double loop 4
   No accessory (secondary) pair of adrostral grooves; post-ocular crest with single loop .. ..
   ......*Penaeus latisulcatus* Kishinouye
4. Main adrostral grooves confluent near hind margin of carapace forming an x-shaped depression .. .. ..
   ......*Penaeus maccullochi* Schmitt
   Main adrostral grooves not confluent near hind margin of carapace
   ......*Penaeus plebejus* Hess
5. Subhepatic ridge present; antennae tigered 6
   Subhepatic ridge absent; antennae plain.. 9
6. Fifth pair of walking legs without exopodites 7
   Fifth pair of walking legs with exopodites 8
7. Colour in life dark buff with grey to black cross bands....*Penaeus carinatus* Dana
   Colour in life vivid blue with dark blue cross bands. . . . *Penaeus caeruleus* Stebbing
8. Postrostral carina distinctly grooved; faint tiger pattern on abdomen only; walking legs striped......*Penaeus semisulcatus* de Haan.
   Postrostral carina not grooved; pronounced tiger pattern on carapace and

abdomen; walking legs plain....*Penaeus esculentus* Haswell.

9. Rostral crest low; dactyl of third maxillipeds of adult male about as long as propodus; colour in life pale tan speckled with blue......*Penaeus indicus* Milne Edwards

Rostral crest high and triangular; dactyl of third maxillipeds of adult male scarcely half as long as propodus; colour in life pale cream, speckled with brown or olive green....*Penaeus merguiensis* De Man

10. A distal fixed pair of spines on the telson (telson trifid); pterygostomian spine present on antero-inferior angle of carapace; stridulating organ present on postero-lateral margin of carapace.... *Penaeopsis* (*Metapenaeopsis*) *novaeguineae* (Haswell).

No distal pair of fixed spines on the telson, but mobile lateral spines may be present in variable number; pterygostomian spine and stridulating organ absent 11

11. Carapace without sutures 12

Carapace with longitudinal or transverse sutures or both 15

12. Telson without prominent spines, but with numerous minute spinules .. 13

Telson with prominent lateral spines .. 14

13. Post-hepatic ridge very prominent throughout its length; first pair of walking legs bispinose; optimal habitat in adult life offshore; colour in life olive green to pink, walking legs with conspicuous red-cream stripes, tips of tail fan purple ....*Metapenaeus incisipes* (Bate)

Post-hepatic ridge faint and only posteriorly developed; first pair of walking legs unispinose; optimal habitat in adult life inside waters; colour in life greenish translucent, walking legs plain, tips of tail fan rich green..*Metapenaeus mastersii* (Haswell)

14. Carapace and abdomen more or less smooth; rostrum usually with 6 teeth; anterior third of rostrum toothless, styliform, uptilted; telson armed with four pairs of lateral spines..*Metapenaeus macleayi* (Haswell)

Carapace and abdomen covered with triangular patches of dense pubescence; rostrum straight, usually armed with 10 teeth, not styliform; telson armed with three pairs of lateral teeth........ *Metapenaeus endeavouri* (Schmitt)

15. Longitudinal sutures only present; carapace and abdomen thickly pubescent; epipodites present on third pair of walking legs; colour in life uniformly reddish .. ..

Longitudinal and transverse sutures present; carapace and abdomen naked; epipodites absent from third pair of walking legs; colour in life tan with distinct tiger pattern of brown, yellow, and blue stripes .. .. *Parapeneopsis sculptilis* (Heller)

16. Epipodites present on first 2 pairs of walking legs .. .. *Trachypeneus* (*Trachysalambria*) *curvirostris* (Stimpson)

Epipodites absent from first 2 pairs of walking legs .. .. *Trachypeneus* (*Trachypeneus*) anchoralis (Bate).

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6

SHRIMP FISHERIES OF PAKISTAN

by

M. R. Qureshi*

ishing Grounds: Of the two units of ı, West Pakistan is situated on the Arabian ll the coast extends for about 500 miles from ian territory on the south-east to the Gwatar the west. It is roughly divided into two , as follows:

The *Sind coast* extending from Sir creek on the south-east to the Hab river on the west. It is about 200 miles long and the major part consists of the delta of the river Indus. It is a low coast except that a few barren hills are found near Karachi. The bed of the sea is mostly muddy and suitable for shrimps, which occur throughout this coast, which is a network of creeks. The main centres for shrimp fishing are Mall, Jhabb, Dabbo, Patiani, Khuddi and Korangi extending to the Karachi harbour.

bruary 1955, a shrimping boat was received through the American aid programme and has struck some shrimp grounds south-east of Karachi. On one occasion 1,200 lbs. of big shrimps (*Penaeus merguiensis*) were caught in one haul lasting about two hours.

(*b*) The *Mekran coast* extends from the river Hab to the Gwatar Bay and is formed of large bays, broken at two places by backwaters. The main fishing centres are Sonmiani, inside Sonmiani Bay, Kalmat situated on Kalmat creek, Ormara, Pasni, Gwadar, Ganz and Jiwani. No exploratory work has yet been done but the data collected so far indicate that Sonmiani Bay, Kalmat creek, Pasni and Gwadar have good shrimp grounds from where a fairly large catch is dried and exported.

Rainfall on the coasts of West Pakistan is scanty averaging about 7 inches.

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rector, Central Fisheries Department, Karachi, Pakistan.

In East Pakistan, the coast mostly consists of mud flats and is about 200 miles long, the richest area being the Ganges-Brahmaputra deltaic region. No survey of the coast has been carried out and the available information is based on the catch of the fishermen. Shrimp grounds exist along the delta and near Cox's Bazaar. Besides the marine shrimps, fairly large quantities of different species are found in the fresh and brackish waters of East Pakistan.

B. Fishing Methods :

Fishing methods are as a rule primitive and conducted in shallow waters. There is no mechanized commercial fishing.

C. Fishing gear and boats :

(*a*) *West Pakistan*—on the coasts of Sind and Mekran the following nets are in use :

i. The beach seine (*Bann*) ranges between 200 to 450 ft. in length, weighted on the lower part and provided with floats on the upper. One end is taken far away in the sea or creek, the other held fast at the beach, the boat is then rowed round and then both ends are dragged ashore by the fishermen. It is a small-meshed net and catches shrimps and small fish. The shrimps are picked up and stored separately in baskets.

ii. The cast net (*Jari*) is used from shore and from small boats in shallow water. This net does not require any description as it is universal.

iii. The stake net (*Arr*) is a fixed net. It is used in the creeks and its mouth is adjusted against the flow of tide. Bamboo poles are fixed in the ground, gradually converging to a point where a floating bag is fixed. The netting tied to the poles directs fish and shrimps to the cod-end, from which they are collected by boat.

iv. There is another type of stake net (*Dora*) which is fixed on a long stretch in shallow water when the tide is up, on the recession of tide shrimps and small fishes are left in the net.

Mechanized fishing has not yet been introduced in Pakistan, although as has been mentioned, a shrimping boat has been received through the American aid programme and a crew has been trained by Mr. L. S. Christey, American Fisheries Adviser in the manipulation of a 100 ft. long flat type shrimp trawl and a 70 ft. long balloon type trawl. The fishing doors are 8 ft. long. Some shrimp grounds have been located. The operations will cont from September onwards after the monsoon.

(*b*) *East Pakistan.* The nets used in catc shrimps, as described by Nazir Ahmed in a p entitled 'Fishing Gear of East Pakistan by Ahmad' presented at the 4th Council Session cast nets, beach seines, trawl nets, stake nets (and others), dip nets and traps. These are oper in shallow waters and in this region also there i mechanized fishing for shrimps. The boats not seaworthy and are all flat-bottomed.

D. Catch Statistics :

It is estimated that the annual catch on the S and Mekran coast in West Pakistan is between 7 to 8,000 tons. The ratio of small to large shri varies according to seasons, as a whole it is appr mately 3 : 1.

In East Pakistan the total catch of freshwa estuarine and marine shrimps is estimated as 5 tons. This is presumably a low estimate.

In West Pakistan the catch of shrimps in 1 was about 7,900 tons. Data collected only Karachi area indicate that the monthly proporti of landings were as follows (for other places data were not available).

January	18.
February	14
March	4
April	1
May	1
June	2.
July	2.
August	3.
September	6.
October	12.
November	15.
December	20.
Total	100

E. Seasonal Variation :

(*a*) *West Pakistan :* For the Sind coast general, it may be said that the season starts October ; and the peak is reached in Decemb January and ends in March. In other mon fishing is mostly confined to the creeks. On Mekran coast, in the Sonmiani Bay and the Kalr creek, the fishing is at its peak during the mon of July, August and September and near Pasni a Gwadar during the months of November to Janua

(*b*) *East Pakistan :* Fishing in the Bay of Ben is confined to five months starting from Octo nding in February, the peak months being mber, December and January. In freshwater, ting the flood season, fishing is done throughe year.

ishery Legislation :

gislation exists in Punjab and East Pakistan for nservation and other aspects of inland fisheries, ld Act has been revised in East Pakistan and der consideration of the Legislature. An act e sea fisheries has been drafted and is now g different stages for final consideration of onstituent Assembly.

rocessing :

ezing : A joint Pakistan-American Company, ational Fisheries (Pakistan) Ltd., has started at Karachi. The Company has a freezer hree cold rooms having low temperature for ing the frozen products for export to the d States of America and other countries. The is capable of freezing 5 tons per 8 hours and storage space for 200 tons. The plant has een working satisfactorily owing to nonbility of raw material. This company is planning to get trawlers and transport boats t enough shrimps may be available to run the

ning : The Sind Canning Company have led a modern canning plant at Karachi and produced some samples. These were sent to d Kingdom, and the reports received have encouraging. Operations will probably ence in September, 1955.

:

West Pakistan : About 95% of the total ction is exported to Burma, Ceylon and in cured condition. The shrimps are boiled urated brine for about an hour till they float surface, taken out of the water and dried in n. The dried shrimps are then beaten with to remove the shell. The finished product ked in gunny bags and exported. The shell exported or mixed with fish meal.

East Pakistan : For keeping the freshness wns for a day or two, these are preserved in d transported to consuming centres, usually kets. For longer storage, three methods are ue, viz., Sun-drying, boiling and sun-drying, noking. In sun-drying the prawns are simply out on mats, in bamboo trays or on raised ms. After drying the shell is removed by g. The finished product is stored in gunny vhile the shells are sold as manure. This is the commonest method followed for curing, especially during the winter months.

For the second method prawns are boiled for a few minutes in fresh water containing a small quantity of common salt. As soon as the shells become soft the water is drained off and prawns are spread out for sun-drying. Smoking is done in smoking chambers in the districts of Bakarganj and Khulna. These smoke-houses locally known as '*Kothi*' are made of forest wood and reeds. The prawns are scattered evenly on raised platforms and smoke is produced by using hard wood. Wood containing much resin and oils is avoided. In a few hours time the finished product with golden colour is obtained. This method of preservation is followed during the rainy season, i.e., April to October, when the prawns cannot be exposed to the sun for a long time at a stretch. During the same season housewives in the district of Bakarganj preserve the surplus supply for home consumption by heating in earthen pans.

Paste :

No shrimp paste is prepared in Pakistan.

H. Marketing and Distribution :

During 1954, out of the total estimated production of 7,900 tons, only 300 tons were sold fresh in the local markets in West Pakistan. The remainder was cured for export yielding 1920 tons in dry condition. The price of fresh shrimps in the Karachi market varied between eight to twelve annas per lb (16 cents to 24 cents U.S.). The export value of the smallest shrimp in cured condition was Rs. 50. (U.S. $15) and the large variety Rs. 123/- (U.S. $40) per hundredweight (112 lbs.)

In East Pakistan the total estimated production during the same period was 4,930 tons out of which about 480 were consumed fresh and a negligible quantity exported in dry condition. The wholesale price range of fresh shrimps in 1952 per maund (82 lb) was 20 to 60 Rupees according to size while in the retail market the price varied between ten annas and two rupees per lb.

I. Biology :

Excepting for some casual observations, very little work has been done in Pakistan on the biology of shrimps. In July and August 1954, when a large quantity of shrimp was landed near Karachi, the gonads showed that this was the breeding season for *Penaeus merguiensis*. Systematic work has started on shrimps and it will be possible to report some results later.

J. Taxonomy : The following species have been recorded from commerical catches of prawns brought to the market :

West Pakistan :

Marine	Local name	Size
1. *Penaeus indicus*		
2. *Penaeus merguiensis*	Jiaro	4″-7″
3. *Penaeus penicellatus*		
4. *Penaeus cannaliculates*		
5. *Penaeus semisulacatus*		8″
6. *Penaeus monodon*		
7. *Matapenaeus monoceros*	Kiddi	3″-5″
8. *Parapeneopsis uncta*		2″-3″
9. *Parapeneopsis stylifera*		
Freshwater		
10. *Palaemon carcinus*		
11. *Palaemon malcolmsonii*		

East Pakistan :

Estuaries	*Local name*	*Size*
1. *Penaeus carinatus*	Bagda chingri	11-12 inche
2. *Penaeus indicus*	Chapda chingri Chapra ,, Chamma ,, Chaga ,,	8 ,,
3. *Leander styliferus*	Ghora chingri	5 ,,
4. *Metapenaeus monoceros*	Honye ,, Kucho ,, & Koraney	6.5 ,,
5. *Metapenaeus brevicornis*	Koraney ,,	5 ,,
6. *Caridina gracilipes*	Ghusa ,, Sunka ,,	1.5 ,,
7. *Cardina propinea*	Ghusa ,, Choanicha	15 ,,
8. *Palaemon carcinus*	Golda chingri Mocha ,, Bara ,, Shala ,,	12 ,,
9. *Palaemon sudis*	Goda ,,	4 ,,

7

PRAWN FISHERIES OF THE PHILIPPINES

by

J. S. Domantay*

The present report aims at listing the major species of prawns in the Philippines and describes the methods used in catching them including details of fishing grounds, and catch statistics.

Several species of Prawns, along with other crustaceans such as lobsters, crabs and mysids provide fisheries of varying magnitude and value in the Philippines, though their commercial value is limited by selective demands of the market based largely on size, taste and availability.

The work so far done on the prawns of the Philippines has mostly been on the systematics of some of the most common species. Some of the reported species have been worked out by naturalists outside the Philippines on material collected and deposited in foreign museums. Professor Eulogio Estampado former colleague of the writer in the Department Zoology, University of the Philippines, and M Guillermo J. Blanco of the Bureau of Fisheri have contributed much to Philippine carcinolog Their works are good sources of information o Philippine crustacean decapods. Blanco an Arriola, Cowles, Villaluz and Villadolid, have als made useful contributions to the study of Philippine prawns.

Studies on the morphology and anatomy Philippine crustaceans of certain importa commercial species have since 1954 been undertake in the post graduate school of the University Santo Tomas under the advisership of the writer.

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* Chief, Division of Inland Fisheries, Bureau of Fisheries, Manila, Philippines..

g the commercially important prawns in
ippines, *Penaeus monodon* Fabricius stands
. Small species of *Palaemon* and *Palae-*
lso occur in abundance, often in big schools.
pecies are : *Penaeus indicus* Milne-Edwards ;
odon var. *manillensis* Villauz-Arriola ; *P.*
ar. *longirostris* de Man ; *P. anchoralis* Spence
. *rectacutus* Spence Bate ; *P. affinis* Milne-
; *P. canaliculatus* Olivier ; *P. canaliculatus*
onicus Spence Bate ; *P. incisipes* Spence
alaemon lagdaoensis Blanco ; *P. talaverae*
P. carcinus Fabricius ; *P. philippinensis*
P. sundaicus Heller ; *P. lanceifrons* Dana ;
frons var. *montalbanensis* Cowles ; *P. jarvensis*
P. lepidactylus Hilgendorf ; *P. latidactylus*
z ; *P. esculentus* Thallivitz ; *P. lar* Fabricius ;
ensis Blanco.

Methods and Gear :

ommon Philippine methods for the capture
ns are grouped into set impounding nets,
impounding nets, entangling nets, guiding
and miscellaneous traps.

Impounding Nets

he bukatot and the diakos.—The *bukatot* is
regular twine net of one centimetre mesh
the catching of penaeid shrimps and crabs,
e *diakos* is made of *sinamay* or *abaca* cloth
hing small Palaemonids. They are small
fathoms or more long and 1-1½ fathoms
h a pocket of from 3 to 5 fathoms and are
strategic places against the current inside
ks or mouths of rivers, attached to a wooden
oo pole at either end. The float line is
with regular wooden floats, the sinker line
d weights touching the bottom. They
ted by one or two men, the pocket is lifted
f an hour intervals, and the catch is emptied
nca or dugout. This is almost a continuous
, the net being removed, washed and dried
e to time. The *tangab*, a filter net used in
ions is another form of the *bukatot*, with a
ut without wings.

plad.—This is a simple method of barricad-
dge of mangrove swamp with sinamay or
oth supported by several poles. At the
f the net is an opening where a pocket
mpot is attached where the shrimps are
as the tide recedes. Mud or stones are
at both sides of the net. In the early days,
al saplad was not provided with the pocket
at number of shrimps got stuck in the mud
d not be recovered. The *lumpot* or pocket
es long and is closed distally by a piece of
When it is full, it is lifted and emptied into

2. *Mobile Impounding Nets*

2.1 *Cast net* (*dala, ataraya, sabokol*).—A conical universally known net, operated by one man and thrown over a school of shrimps or fish. It is heavily weighted around the base, and provided with a retrieving line attached to the apical portion. The size varies from a small, shore-operated net to a large one used in conjunction with a *vinta*, a sharp-keeled dugout with outriggers on both sides, propelled by a sail in deeper waters.

2.2 *Push net or scissor-net* (*sakag*).—This is the most common gear used. It is operated by one man who pushes it on tidal creeks, rivers and shallow shores with a smooth sandy-muddy bottom. It is usually made of fine-meshed net mounted on a triangular frame of two bamboo poles bolted at an angle point where the two poles meet. The angle of the poles can be increased or decreased during operation. The distal ends of the two poles are fitted with a shoe-like device made of wood or coconut husk to facilitate the pushing operation. It is used more effectively during dark nights and during new moon. Fig. 4.

2.3 *Skimming net* (*anod-sulong*).—It is similar to the push net but operated in deeper waters from a small dugout, or raft. The net is attached to one side of the craft which is pushed along with paddle or pole, causing a skimming motion of the net. Fig. 5.

2.4 *Drive-in-net* (*Surambaw*).—Various forms of framed or unframed lift nets operated with a scare-line.

2.5 *Lever net* (*salambaw*).—A large, rigidly-framed lift-net mounted on a bamboo raft and fished by a dipping motion of a lever-like arrangement. It is mainly operated for mullet and other smaller fishes but it is also used for catching shrimps. There are slight modifications in form and operation.

2.6 *Drag nets.*—Among the pull or drag nets the Japanese *utase* (beam trawl) and the otter trawl are the most common ones used in many fishing grounds, particularly around Manila. It is mainly intended for fishes but is also used extensively for the crustacean fisheries. The otter trawl is gaining popularity among the successful trawlers nowadays in the Visayan fishing grounds. At present there are more otter trawls registered than beam trawls.

2.7 *Dip-net* (*panalok*).—A scoop made of non-textile webs in which the capture of shrimp and fish is effected by a baling or dipping action. This is used in scooping out the catch from the collecting pound of fish corrals.

S\3/7

2.8 *Cover pot* (*salakab*).—This is an entrapping device having a non-return valve. It is mainly used for catching mudfish (*Ophicephalus striatus*), in rice fields and in inland bodies of fresh water during the day, but during dark nights it is used with torches and flash lights for catching crabs and Penaeid shrimp along the mouths of rivers, mangrove swamps and along the shallow coastline, particularly during low tide.

3. *Entangling Nets*

3.1 *Panti.*—This is a sort of gill net for shrimps and crabs. It is made from a No. 40 twine with a 1.5 inch mesh, 1.5 metre depth and a length of 55 metres. The float line is provided with rounded, light wooden floats of *tuwi*, a kind of light wood, and laced at intervals of half a metre. The lead line is provided with sinkers of 2 centimetres diameter at intervals of one metre. The net is usually dyed with extracts of *bakawan* bark. At least a dozen units of this net are joined together during fishing operation. The net is paid out in a semi-circle, starting from a buoyed anchor with the aid of a motorized boat. After paying out the net, the boat goes around facing the concave portion of the net, and with the noise of the engine the shrimps and the fishes are driven into the net and are gilled through the meshes. After this operation the men in the boat pull up the other end of the net and haul it on board. The operation is repeated continuously from 4 to 10 a.m. After the operation the entire net is removed, washed and dried in preparation for the following day's operations.

4. *Miscellaneous Fishing Devices*

4.1 *Fish shelters* (*sapatan*)—are anchored or suspended bunches of grass or weeds, which offer refuge for shrimps, and from whence they are captured by devices operated in different ways. When the *sapatan* is anchored or submerged in shallower waters, bamboo matting (*banata*) is used to surround the fish shelter before the shrimps are bailed out. When it is suspended in deeper waters, a dip net made of sinamay may be used in catching the shrimps. Finely woven baskets may be used in place of the dip net. The sapatan is similar to some extent to the *panugpo*, a fish shelter for catching young shrimps and various other fish fry, in which bundles of grass or weeds are suspended to a long line of rattan or rope at regular intervals. The young of *Penaeus monodon*, locally known as *sugpo*, take refuge in the bundles and are caught from July to October in places around Manila.

4.2 The *bonbon* fish shelter should not be mistaken for the *panugpo* which is also known as ' bonbon ' by some fishermen. The bonbon is compos
brush piles at strategic places where shrimps
fishes take refuge. After some time, the b
piles are surrounded by bamboo matting and t
removed before catching the shrimps and fis
with dip net or other device.

4.3 The *lawiswis* is a gear composed of an ordin
dugout with an outrigger on one side and fin
woven bamboo matting (*banata*) on the other
which in shallow waters prevents the shrimps
fish from passing underneath the boat but sca
them into the moving dugout.

5. *Guiding Barriers*

The fish corral (*baklad or bunsod*)—is made
finely woven bamboo matting (*banata*) usually pla
in shallow waters for catching shrimps. In the I
fishpond, a small fish trap (*bunsod*) is planted ins
the fishpond near the main gate for catching
during high tide and shrimps when the water rec
during low tide, particularly at night. Similar
is planted in tidal creeks inside mangrove swar
mainly for catching shrimps. The small fish co
(*tankub*) also used in Iloilo fishponds has one
pounding chamber (*bolsa*) with wings, while th
planted in tidal creeks inside mangrove swamps
other shallower places near the mouth of ri
lagoons, coves, etc. have two compartments a
wings (*pikpik*). The *palapad* is similar to
saplad (see. 1.2) in operation except that inst
of the sinamay or abaca cloth, bamboo matting
used. It may or may not have the impound
chamber. The *palapad* is intended for catc
bigger Penaeid shrimps and fishes whereas
saplad is for smaller ones and the smaller spe
of Palaemonid shrimps. These gears are operat
only during the new and full moon.

Fishing Grounds :

The Palaemonids are usually found inside co
and bays, and at times in mangrove swamps du
high tide. The neighbourhood of Margosatu
in Zamboanga del Sur, and around Bato-bato
other places in the Sulu Archipelago are among t
principal Palaemonid fishing grounds in the Sou
The penaeid shrimps are found practically all ov
the Philippine waters from the shallow mangro
swamps to the deeper fishing grounds inside ba
gulfs, and seas.

Catch Statistics:

Table I represents the volume of penae
shrimps gathered from the different fishing groun
from 1951 through 1953.

Table I

Penaeid Shrimp Catches

g Areas	Shrimps in Kilograms		
	1951	1952	1953
..	14,772	9,873	16,089
Channel ..	..	..	
Coast ..	..	..	126
it ..	..	345	1,860
st ..	..	..	17,235
st ..	60	3,066	
Bay ..	31,770	27,300	50,817
Channel ..	1,485	..	
Strait ..	258,588	206,397	121,182
y	1,740	..	
y ..	..	240	
f ..	1,950	3,126	
Gulf ..	7,353	8,484	12,219
a Sound ..	1,500	156,384	25,665
y ..	308,733	176,355	280,272
Bay ..	16,068	121,569	353,982
f ..	..	..	20,319
f ..	76,272	50,526	29,631
..	286,851	180,669	284,508
l Bay ..	17,448	39,927	100,788
ea ..	..	210	4,425
..	23,556	22,578	33,603
ay ..	1,704	17,544	21,372
a ..	145,683	286,782	244,278
Total ..	1,195,533	1,311,375	1,618,371

I gives the yearly catch of Penaeid shrimps ns from 1948 through 1953 by the licensed commercial fishing vessels over three tons acity). Catches by gear other than the re not included in this table for lack of data.

Table II

Trawl Catches

Year	Penaeid shrimps in kilograms
.. ..	996,015
.. ..	877,448
.. ..	1,092,996
.. ..	1,195,533
.. ..	1,311,375
.. ..	1,618,371

e seen that from 1950 to 1953 there is a rease in the catch of the penaeid shrimps, due to the gradual increase in the number ed trawlers during the period, as is seen II.

Table III

Registered Number of Commercial Fishing Vessels Using Trawls

Kinds	1949	1950	1951	1952	1953
Beam trawl ..	166	157	131	56	51
Otter trawl ..	58	129	190	234	227
Total ..	244	286	321	290	278

There was a gradual increase in the number of trawlers from 1949 to 1951 followed by a decrease in 1952 and 1953. There was, however, a consistent increase of the catch of penaeid shrimps from 1949 to 1953.

The statistical records for the penaeid shrimps are, however, far from complete. Not all the penaeid shrimps caught by the trawlers were accurately reported with the exception of those that were supervised and inspected by the Bureau of Fisheries personnel. The tendency on the part of the fishermen is to report less in order to pay less fee. The catches of shrimps caught by gear other than the trawlers were never reported.

Processing :

A good portion of the penaeid shrimps particularly those caught by the trawlers, are processed into the dried product known as *hebe*. They are boiled and salted and then partially sun-dried, after which, the exoskeletons are removed mechanically and the meat is further dried and packed for the market.

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8

SHRIMP AND PRAWN FISHERIES IN INDONESIA WITH SPECIAL REFERENCE TO THE KROYA DISTRICT

by

R. Roestami Djajadiredja and M. Sachlan*

The object of this paper is to give an impression of the present situation with regard to the problems pertaining to shrimp and prawn fishery in Indonesia, from the viewpoint of its status within the framework of fisheries in general. Our knowledge on the several aspects of this subject, e.g. the significance and the intensity of the shrimp and prawn fishery, the fishing grounds, the methods of capture, etc.—is still very limited. Efforts to shed some light on the shrimp problems have been initiated but a few years ago, and have as yet not yielded any positive results.

In 1940, a conference was held at the Laboratory for Inland Fisheries to discuss the shrimp situation in Indonesia, especially with regard to pond-shrimps (udang tambak), resulting in the publication of 'Voorlopig overzicht van enkele economisch belangrijke tambakgarnalen', by de Jong. Schuster, who during the period between 1929 and 1942 had gained considerable experience in the field of coastal ponds, contributed substantially to the knowledge concerning pond-shrimps.

Whereas there is some literature on the subject of pond-shrimps, the field of marine shrimp fishery has not, as yet, been subjected to any extensive scientific investigation.

The same can be said with regard to freshwater shrimp fishery. In his 'Bilder aus der Binnenfischerei auf Java und Sumatra', Thienemann dropped a word on the freshwater shrimp fishery, mainly in lakes. The foregoing gives us a picture of what has been done in the scientific field on the subject of the shrimp fishery in Indonesia.

Scientific literature dealing with the biolo aspects of shrimps in Indonesian waters is existent. On the other hand, scientific data on taxonomy and zoogeographical distribution available. De Man and Roux have done em work in these fields.

Classification of Shrimp and Prawn Fishe

As is the case with fisheries in general, shrimp fishery in Indonesia covers a wide terri Its fishing grounds coincide with those of fish can be divided as follows :

1. marine zone (onshore waters);
2. brackish water zone (coastal ponds, r mouths, lagoons and coastal lakes).
3. freshwater zone (lakes, irrigation ta swamps and rivers).

A great number of shrimp species is foun Indonesia, the scope of this paper will be lin to the economically important species.

1. Marine and Brackish Water Shrimps :

a. 'Terasi' shrimps

The term *udang terasi* (shrimps for paste) is widely used among Indonesian fishermen, but technical term used in government serv Common people are more familiar with the na *rebon* and *djembret* (by *rebon* is understood a mix of different transparent shrimps, the size of w varies between 3 and 20 mm) consisting main Mysids.

Rebon exist in very large numbers in co heir availability coinciding with the period tides, i.e. during the months April-May- and November-December-January. In onds, *rebon* provides the population with a al additional income.

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* Inland Fisheries Research Officer, Laboratory for Inland Fisheries, Bogor, Indonesia.

et is a collective name denoting all kinds of with a size varying between 0.5 and 1.5 cm. likewise consists of a mixture of small- ysids and larvae of other genera. The in *djembret* mixtures of Penaeid larvae is of ortance as a supply for the coastal ponds. rimps are found in coastal waters, river lagoons and brackish water ponds.

rebon and *djembret* are usually used for g *terasi*, a paste-like product, which owing eapness is in great demand, and which s an important source of protein for the n.

rger sized *djembret* is partly dried or used redient for the manufacture of *krupuk udang* crackers).

nsumption shrimps

nption shrimps consist mainly of the family , belonging to the order Decapoda. he sixteen genera represented in Indonesia, are economically important, i.e. Penaeus eopsis (for an enumeration of species see ition '). Other species are sporadically xed in catches, e.g. *udang barong* (lobster, sp.), *udang pletok* (*Alpheus* sp.), etc., but comparatively unimportant and will not be further discussed in this paper.

sumed in scientific circles that the penaeids spend their infancy in coastal waters. On ng sexual maturity, they return to their origin in the open sea, to engage in re- e activities. In America, scientists have in finding their spawning grounds, but ot the case in Indonesia, and consequently rimps have not yet attained great economic e. According to information received, nature shrimps have been caught in a few ar the coast of Djapara (Central Java), and angka Strait off the estuary of the Musi chuster likewise reported similar catches antas delta (East Java) and off the coast of (West Java), but up to the present these have not been subjected to commercial n.

enaeids sold in great quantities on the ome from catches made in rivers, coastal l lakes, lagoons or coastal ponds. They are ught by different kinds of shrimp traps *ang*, *waring*, *tugu udang* etc.). Among the most important fishing-grounds are Bagan Si Api-Api (East Sumatra), the delta territories of the Musi River (South Sumatra), and the river mouths in Java and Borneo. The shrimp larvae, taken along by the current, enter brackish water ponds through the sluice gates. Afterwards their exit is impeded by closure of the gates or by an intervening bamboo screen, and thus they are ' cultured ' in the ponds. It seems that pond shrimps are larger than those caught in open waters, attaining a size of between 10 and 15 cm. in about one month.

The most important variety of pond shrimps is *Penaeus indicus* var. *longirostris* (de Man), whereas *P. semisulcatus* (de Haan) which attains lengths of 20-25 cm., while very much appreciated for its size, occurs in much smaller quantities.

At present there are about 129,000 hectares of coastal ponds, including 93,000 ha. in Java and Madura. Full statistical data on pond shrimp production outside Java are not available yet. Table I shows the volume of shrimp and fish sold on the markets in Java.

Schuster estimated the total annual shrimp production in the ponds of Java and Madura at 3,328 tons, constituting 21.5% of the total production. For a detailed account of shrimp imports we refer to the same author.

For the most part these shrimps are sold fresh; the remainder is preserved in the form of different kinds of dried shrimps, *ebi*, *bekasem udang*, *dendeng udang* and crackers (*krupuk*).

2. Freshwater shrimps :

In Indonesia, freshwater shrimps are represented by the families Palaemonidae and Atyidae of the Encyphidaea (Caridea), belonging to the order Decapoda. The Atyidae consist of the genera Caridina and Atya, whereas the Palaemonidae are represented by the genus Palaemon (see Table IV).

The freshwater shrimp fisheries are of very great importance to the Indonesian household. Indonesia is very rich in inland waters, such as lakes, reservoirs, swamps, rivers, *sawahs* (flooded rice fields) etc. and almost every pool is populated by shrimps.

Men, women and children alike participate in fishing in these waters, and it constitutes a source of income and protein for the common people.

The most appreciated species of the genus Palaemon is *P. carcinus* Fabr. This species is large-sized and when mature, may reach a length of slightly more than 30 cm. It is found all over Indonesia in rivers and marshes which empty into the sea. Specimens of this species have never been caught in swamps or lakes without an outlet to the sea. Other species of this genus are much smaller, ranging between 4 and 10 cm.

The shrimps belonging to the genera Caridina and Atya (*udang grago*) are much smaller than the Palaemons. Being no larger than 1.5 to 3.5 cm., they can be compared with *djembret*. Their importance lies in their vast numbers.

This kind of shrimp is caught under almost the same conditions all over Indonesia (see below: shrimp fishery in Kroya District).

Freshwater shrimps are mostly sold in fresh condition in the markets and only a very small part of the *udang grago* is dried, trade in this product being mostly of local character.

Distribution :

In order to get a clear picture as to what species of shrimps are represented in Indonesian waters a table enumerating the economically important shrimp species belonging to three families i.e. Penaeidae, Palaemonidae, and Atyidae, is given in Table V.

Fishing Gears :

The gears used for catching shrimp are of various similar types throughout Indonesia. For a detailed account see ' Fishing gears in Indonesia ' by Kartono presented as a Technical Paper at the 6th IPFC Session and the description given below relating to the district of Kroya.

Shrimp fishery in the Kroya region :

The author was assigned for a period of three weeks to make an investigation into the conditions existing in the Kroya district and the foll
information while relating specifically to that r
is considered to be typical of many plac
Indonesia. The survey will be continued
coming season.

The shrimp fishing grounds around Kroy
situated in the southern part of the Rege
Banjumas in Central Java, being a part of the
of Sumpiuh. In the West this plain is sep
from the large swamps around ' Segara A
by the Seraju river. In the north, this pl
surrounded by the ' Kendeng ' range, 200 t
metres high and consisting of tertiary stone f
tions. East of the plain we find 300 to 400
high lime-stone hills (also a tertiary formatio
its southern border is settled by a rid
sand-dunes.

The altitude of the whole plain which c
mostly of rice fields and marshes, varies from
10 metres above sea level. All the water from
rice fields and other bodies of water flows do
the South Coast into the Indian Ocean via the
of Seraju, Bengawan and Bodo. Shrimp fish
carried on especially in the two latter rivers,
are tidal, and in marshes and other bodies of
scattered over the area. The total length
rivers in which shrimps are caught is estima
221 kilometres.

The tide of the Indian Ocean, in which
rivers end, is diurnal, the mean range on the
coast (Tjilatjap) being about two metres.

TABLE I

Total production of brackish water ponds in Java and Madura 1953-54

Province	Total acreage of brackish water ponds	Yield of Shrimps kg.	Yield of Chanos kg.	Yield of extraneous fishes kg.	To
1953					
West Java	18,848	828,000	823,000	1,451,000	3,102
Central Java	19,492	1,068,000	1,362,000	1,936,000	4,366
East Java	48,706	3,500,000	10,162,000	1,700,000	15,362
Total ..	87,046	5,396,000	12,347,000	5,087,000	22,830
1954					
West Java	23,566	657,000	609,000	712,000	1,978
Central Java	20,557	1,914,000	1,971,000	2,043,000	5,928
East Java	48,843	3,600,000	10,188,000	1,800,000	15,588
Total ..	92,966	6,171,000	12,768,000	4,555,000	23,494

TABLE II

Total catch of Shrimps in Java and Madura 1954

Resort Province	Shrimps kg.	*Rebon* and *Djembret* kg.	Total kg.	Value of Shrimps Rp.	Value of Rebon and Djembret Rp.	Total value
West Java	250,000	29,000	279,000	1,023,000	60,000	1,083,000
Central Java	..	515,000	515,000	..	806,000	806,000
East Java	43,000	193,000	236,000	132,000	301,000	433,000
Madura	16,000	1,089,000	1,105,000	53,000	1,791,000	1,844,000
Total ..	309,000	1,826,000	2,135,000	1,208,000	2,958,000	4,166,000

TABLE III

Imports of shrimp paste (*terasi*) into Java and Madura 1939-41 and 1947-49

	Gross weight in metric tons	Value in 000's of Rupiahs
.. ..	113	21
.. ..	167	31
.. ..	37	8
.. ..	1,150	1,189
.. ..	361	186
.. ..	45	26

TABLE IV

of Dried Shrimp (*udang kering*) and Shrimp Paste (*terasi*) from Indonesian Provinces (principally Sumatera) (1) to Foreign Countries 1939-41 and 1947-49

	Dried Shrimp (*Udang kering*)		Shrimp paste (*Terasi*)	
	Gross weight metric tons	Value 000's Rupiahs	Gross weight metric tons	Value 000's Rupiahs
.. ..	589	114	341	33
.. ..	378	88	495	63
.. ..	508	102	594	57
.. ..	11	27(2)	—	—
.. ..	2	1(3)	—	—
.. ..	136	321(3)	9	3

umatera—Sumatra
ther provinces only (Not Sumatera)
umatera only

TABLE V

Species	Sumatra	Borneo	Java	Sulawesi	Lesser Sunda Islands	Molluccas	Type of wat	
							fresh	brackish
Atya moluccensis de Haan ..	×	×	×	×	×	—	×	
,, *brevirostris* de Man ..	—	—	—	—	×	—	×	
Caridina laevis Heller ..	×	—	—	×	—	—	×	
,, *wyckii* Hickson ..	—	—	—	×	×	—	×	×
,, *weberi* de Man ..	—	—	—	×	×	—	×	
,, *gracilirostris* de Man ..	×	—	—	×	×	×	×	×
Palaemon carcinus Fabr. ..	×	×	×	×	×	—	×	×
,, *elegans* de Man ..	—	—	×	—	—	—	×	
,, *lar* Fabr. ..	—	—	×	×	×	×	×	×
,, *javanicus* Heller ..	×	—	×	×	—	—	×	
,, *pilimanus* de Man ..	×	—	×	—	—	—	×	
,, *pilimanus* var. *leptodactylus* de Man ..	×	—	×	—	—	—	×	×
,, *sundaicus* Heller ..	—	—	×	×	×	—	×	×
Penaeus semisulcatus de Haan ..	×	×	×	×	×	×		×
,, *indicus* var. *longir Fostris* de Man	×	×	×	×	×	×		×
,, *canaliculatus* Oliv. ..	—	—	×	×	—	—		×
,, *merguiensis* de Man ..	×	—	—	—	—	—		×
Penaeopsis brevicornis H. M. Edw. ..	×	×	×	×	×	×		×
Penaeopsis monoceros Fabr. ..	×	×	×	×	×	×	×	×

× = present
— = not present

During the west monsoon, when the rivers are swollen with great quantities of fresh water, sea water can only penetrate 1½ to 3 kilometers into the rivers, but during at least two months in the dry season, sea water can reach the villages of Medang and Sikamphuh (12 km. and 16 km.) so that almost all the river system becomes brackish. Owing to the diurnal tide, sea water moves upwards twice daily during high tide and flows down again during the ebb.

One can tell the influence of the tide by the flora and fauna along the rivers. In a dry east monsoon, the fresh water fishes and shrimps are forced up the river and can only be caught in the swamps around Rawa Telar and Rawa Mudjur, while marine fishes and shrimps are caught in large numbers in the rivers and marshes near the villages Sikampuh and Kedawung. During the rainy season this situation will, of course, be reversed.

Great daily fluctuations in salinity directly caused by high and low tide take place only to the south of Patilasan and upstream the salinity is constantly low, except in the dry season. This is clearly shown by the vegetation along the rivers. Avicennia, Rhizophora and Soneratia are not so much represented here, but are still visible among the nipah trees (*Nipa fructicans* Wurmb.), representing the main vegetation along rivers and swamps. Somewhat north of the village Patilasan (4.75 km. from the sea) the *wlingi* (*Scirpus grossus* L.) can be
representing the main vegetation beside the
and the *djerudju* (*Acanthus ilicifolius* Linn.)

Regarding the fauna, many crabs (*Scylla*
Forsk) are caught South of Patilasan, and other
of small crabs (Brachyura) (Sesarma, Met
Uca etc.) are to be seen along the river bank
on the tidal flats. ‘ Cones ’ of the so-called ‘
tanah ’ (*Thalasinus anomala* Herbst) are also abu
On the muddy river banks various kinds of ‘ *be*
or mud-skippers (*Periophthalmus*, *Boleophth*
can also be seen.

Along the rivers and ditches there are
swamps which are inundated at high tide and
entirely drained at low tide. Collecting of sh
and fishes is carried out in the swamps as
in the traversing ditches.

There are several marshes in the upper
the Bengawan river, of which the shallow par
used for rice cultivation during the dry
According to a recent estimate by the local
Administration Office, the total surface of
marshes in the wet season amounts to 955 hec
A good deal of shrimps sold in the market of
the main town of this area, originates from
marshes. In Rawa Mudjur and Rawa Tela
shrimp catch consists mostly of freshwater
throughout the year.

of Soil

e soil of the plain of Kroya consists for the r part of alluvial river and marine sediments, tter predominantly in the southern part of ea, forming a 4 to 5 kilometres wide strip l to the coast.

er sediments deposited by the Seraju, wan and Bodo Rivers, consist mainly of loam lay, to a certain extent mixed with sand and , while marine sediments for the greater part t of andesitic-dune-sand slightly mixed with nd clay from the rivers.

itation

ya district is one of the places in Java with rainfall (3,200 mm.). The months of July ugust are the ones with minimum rain, viz. nd 150 mm., while for October-December nthly figures range from 380 to 470 mm.

n January, the rainfall gradually decreases he month of July.

ing the rainy months October-November, ter level rises in the rivers and marshes. In places the main rivers overflow their banks, rge areas of rice fields are flooded.

rature

ing the three weeks (February 24-March 12, of our investigation, the temperature in the s of Kroya fluctuated between a minimum emperature of 25°C. at night and a maximum C. by day, although the water temperature in r swamps with depths ranging between 20 cm. might rise as high as 37°C.

al analysis of the water

he rainy month of March 1955, physico- al analyses of the water were carried out at n different places in this area.

e rivers, as well as in swamps and marshes, our of the water was yellowish due to its of colloidal mud; the visibility ranged from 5 cm., measured with a secchi-disc. Because f the water originates from or passes through mps and marshes, it has a rather high content nic substances.

rmination of the quantity of organic matter Winkler '10-minute method' showed the 20 to 30 mg. $KMno_4$ per litre. The pH anged from 6.6 to 7.2, the water showed a ffer capacity (Ca $(HCO_3)2$). The alkalinity vater was 0.5 to 1.2 with 14 mg. to 33.6 mg. r litre: the figures 0.5 and 1.2 indicate the of cc. of 0.1 n HCl used for 100 cc. sample, ethylorange as indicator.

At one station near Adiradja on the Bengawan River about three kilometres from the sea, where there was an admixture of sea water at high tide, the pH value was rather high, ranging from 7.0 to 7.6 while the alkalinity was 1 to 2.1. The chlorinity was also determined at various places by an $AgNO_3$ solution. The analyses show us that the water in the rainy season contains about 2 to 30 mg. of Cl per litre, although the chlorinity of the Bengawan River near Adiredja was, of course, much higher, amounting to 3,750 mg. at high tide and at low tide 343 mg.

Micro-flora and fauna

Due to the turbidity and the quick flow, there is very little phytoplancton in the rivers and such phytoplancton as is seen in the samples seems to have come from the marshes. On the other hand, both the rivers and the marshes around Kroya contain a fair amount of zooplancton, belonging to the Protozoa, Rotatoria, Cladocera and Copepoda; these waters also contain much detritus, which might serve as food for those organisms. In the Bengawan River near Adiredja where tidal fluctuation is more distinct, the micro-flora and fauna change with every tide; during high tide, the plancton consist mostly of brackish water micro-organisms, (e.g. Diatoms) and also contains many nauplii or young shrimps.

At low tide on the other hand freshwater micro-organisms predominate and are mixed with those inhabiting the two types of waters. During the dry season, in which all the rivers become brackish, the organisms typical of brackish waters will presumably predominate.

The marshes too have a low content of phyto-plankton, although the water is stagnant, owing to the turbidity of the water. Protozoa, Entomostraca and Rotatoria are abundant in the marshes as well as small quantities of desmids.

Much Epiphyton consisting of Diatoms, Cyanophycae, Rotatoria, Protozoa and Chlorophycae is to be found on living aquatic plants and serves as natural fish food.

Species of prawns caught

Twelve species of prawns (Table VI) are recognized in the commercial catch. Five of them are called *udang tambak* (udang = prawn; tambak = pond) belonging to the Penaeidae. The penaeids normally migrate from the sea and stay for some time in the coastal waters. These prawns form, beside milk-fish, an important part of the yield of brackish water ponds. Penaeids sold in the Kroya markets are smaller than those originating from ponds. *Penaeus semisulcatus* (de Haan) and *Penaeus indicus longirostris* (de Man), which in ponds may reach a length of 20-25 cm. and 12.5-20 cm. respectively, are caught here at a size of 6-10 cm. (exceptionally of 15 cm.) and 6-8 cm. It seems that these species do not reach the length found in the ponds, because by that time they have either already returned to the sea or have been caught. Our present knowledge concerning the life cycle of these Penaeids is very limited. It is obvious, however, that these prawns do not reach sexual maturity in inland waters. They spawn at sea and move inshore as larvae, returning to the sea for spawning before reaching sexual maturity.

Other kinds of prawns belong to the freshw families Palaemonidae and Atyidae and ma considered as real freshwater inhabitants, pa their whole life cycle in the inland waters. contrast with the Penaeids, the eggs of these 'f water prawns', usually carried by the females laid in these waters. *Palaemon carcinus* Fab very common species in Indonesia, has the hig value owing to its larger size. The biological as of this prawn will be studied in the near fu The people of Kroya have raised the fry of prawn to a length of 16-20 cm.

TABLE VI

Species of Prawn found in the Kroya area

Species	Freshwater	Brackish-water	Sea
Penaeus semisulcatus de Haan	—	×	×
Penaeus indicus var. *longirostris* (de Man)	—	×	×
Penaeus canaliculatus (Oliver)	—	×	×
Penaeopsis monoceros (Fabr.)	×	×	×
Penaeopsis brevicornis (H.M. Edwards)	—	×	×
Palaemon carcinus Fabr.	×	×	×
Palaemon sundaicus Heller	×	×	—
Palaemon pilimanus var. *leptodactylus* de Man	×	—	—
Palaemon elegans de Man	×	—	—
Palaemon lar Fabr.	×	×	—
Palaemon sp.	×	×	—
Caridina sp.	—	—	—

× = present — = not present

The composition of the catches naturally differs according to the distance from the coast. In the waters north of Gemarang Palaemon and Caridina species predominate, whereas south of this place marine shrimps predominate.

All the species of prawns shown in Table VI are known to the people in the Kroya area by only seven local names, *e.g.*: Tepus, Mendjangan, Dlemek, Watang, Bokol and Grago-prawn. Other names used are synonymous with these. Thus, the name of *Bokol* prawn is a collective name for several small species of prawn of the genus Palaemon, whereas *User Wedi* and *Mendjangan* both include two species of prawns.

Catching season

Generally speaking prawns are available in the markets throughout the year, although the quantity fluctuates in accordance with the intensity of the catch.

Palaemon carcinus is caught throughout the year. The peak of the catch is at the beginning of the rainy season, in the months of November-December. High yields of these prawns are usually obta when the water level in the swamps suddenly d after a period of flood.

It is supposed that Caridina spp. are caught in rainy season, especially during the months January-March.

Regarding prawns migrating from the sea, i said that maximum catches of the *udang tepus*, *u* *putih* and *udang kuning*, occur during the dry sea in the months of June-August, while in the ra months they are caught in small numbers only.

The peak season of *udang dlemek* (*Penae* *monoceros*) may occur in the months of Janu February, though they are present at other tim

The capture of prawns with screening de will be affected by the height of the tide, the inten of the current, and also by continuous rainfall.

The prawn fishery is largely a secondary occu tion. This has an effect on the quantity of pra on sale at the markets, as when there is much w on the rice-fields there is little fishing.

ng methods and gear

principles involved in the capture of prawns rshes and in rivers are somewhat different to the difference in water flow. In the more stagnant water of the marshes the methods are based on 'active fishing', while in the strong t of rivers it is based on 'passive fishing'. first case the gear is placed where prawns can pected and measures are taken to attract the s into the gear. In the second, the prawns l along by the current are screened out.

ching operations in rivers and river-mouths regarded as a primary occupation, and those rshes and flooded rice-fields as a secondary

rs used in rivers and river-mouths are normally and stronger in construction and are applied extensively. The farther upstream, the r is the size of the gears and the weaker their uction. In rivers and river-mouths, the are used in series attached to strongly built ures, whereas higher upstream and in the es individual units are used.

ication of gear

gears used are as follows :

Movable

Nets :

1. Seser = skimming-net
2. Nonok = push-net

related to this are the Tedong, Langkar and Krandak

3. Djala uwur = cast-net

Fixed

Fykes and traps :

1. Bubu kretjekan = common trap
2. Bubu djarang = filter fyke
3. Bubu biasa = common ,,
4. Bubu tadah = filter trap
5. Bubu pantongan = filter fyke
6. Bubu wide = bamboo-screen trap

Nets :

1. Antjo, brandjang, djodang, (lever nets)

sser or skimming-net (Fig. 1)

iption : This gear is generally used in lonesia. Shape: triangular and without ft. Measurements: slope 75 cm., base 45 cm.

Material : The net is made of 'waring' (fine meshed netting of agel fibre (*Corypha utan* Lamk) with a bamboo shaft. Usually this net is not preserved.

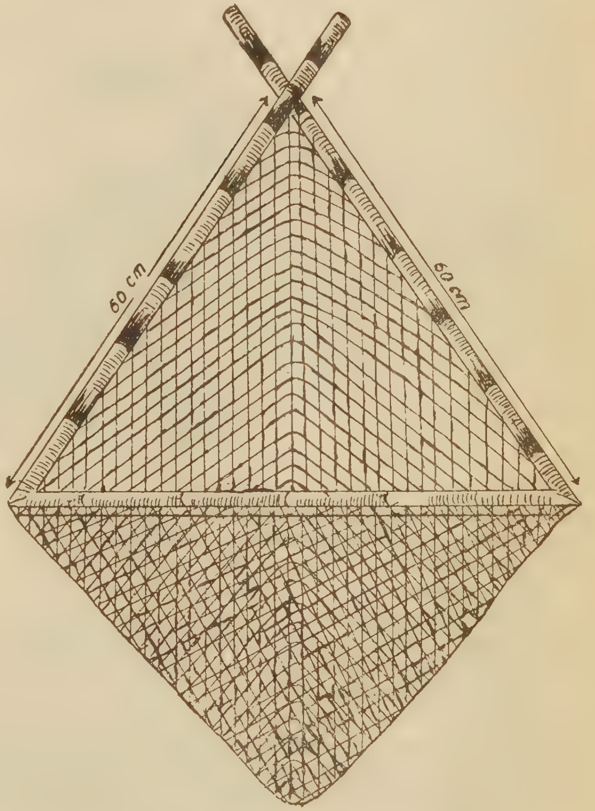

FIG. 1. Sesser (Skimming-net)

Operation : Operated by one man, in shallow places, as along the banks or shores. The gear is pushed underneath aquatic plants and grasses to be lifted at the end. It is used by day as well as by night. The yield consists of shrimps and small fishes. In three to four hours one man can catch from one half to one Kilogram.

The Nonok, Tedong, kerandah, langkar (push-net—Fig. 2)

Description : This gear is probably an improved type of skimming-net and is in common use in Indonesia in marshes, lakes and ditches not deeper than 1 meter. All the nets are triangular in shape and are tied to a bamboo frame, with a bamboo shaft. The shaft of 'kerandak' is somewhat bent, the sack longer.

Material : The net is mostly made of 'agel' with a mesh of 10 mm. Nets made of cotton yarn mostly have bag made of 'agel'. Frame and shaft are made of bamboo, except the 'Langkar', of which the shaft is made wood. The junction between the frame the shaft, called *telobong*, is always made wood.

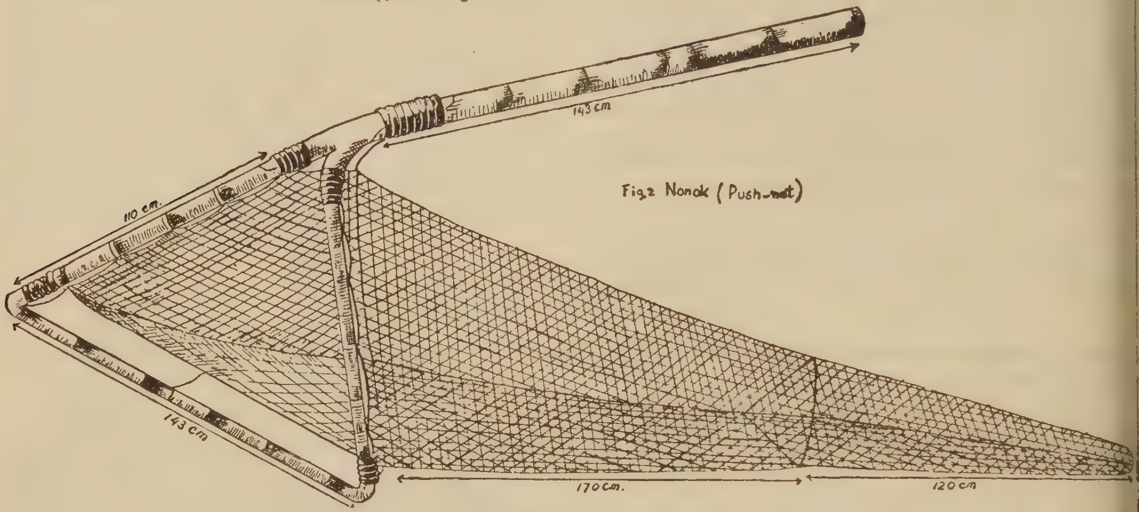

FIG. 2. Nonok (Push-net)

Operation : The gear is pushed forward while wading in the water mostly against the current and the yield is collected at intervals of 20 to 30 metres. If used in muddy places the net is pushed at about 20 cm. from the bottom. In marshes this gear is used during the day as well as at night. In three to four hours this gear may yield 2 to 3 kg. per man.

The Djala uwur, or cast net (uwur = bait)

Description : This is the universally known cast net, 2 m. long, with a mesh of 15 mm in the upper and 25 mm. in the lower part. It is mostly used for the capture of *Palaemon carcinus.*

Material : For the upper part cotton yarn No. 30/6 and for the lower No. 30/9. Ring shaped sinkers are made of lead.

Operation : Used in deep rivers and marshes (1½ to 3 m.). The bait, made of rice bran sometimes mixed with *bungkil* or pressed peanut cake, mixed with clay to make it sink to the bottom, is made into balls which are dropped into the water at about 2 to 3 m. from the bank.

Fishing is mostly done during the day bef the tide reaches its highest level, when current is weak.

Bubu kretjekan—common fyke

Description : Conical shaped fyke with two n return devices. Length : 85 cm ; diameter cm. at the opening and 6 cm. at rear end.

Material: This fyke is made of split bamboo 2 m wide. The shape is fixed by bamboo hoo The rear end is closed by a coconut shell.

Operation : This gear is used near the ban where at a depth of about 1 m purpose ridges are constructed. The fykes are pla at the corners of these ridges with the open facing the open water. Used at day time well as at night. Fykes are emptied three ti a day. Daily yield per fyke ½-1½ kg. of praw

Bubu djarang—filter trap—Fig. 3.

Description : Bigger type than the preceding Length 120 cm., front diameter 35 cm., rear 9 cm.

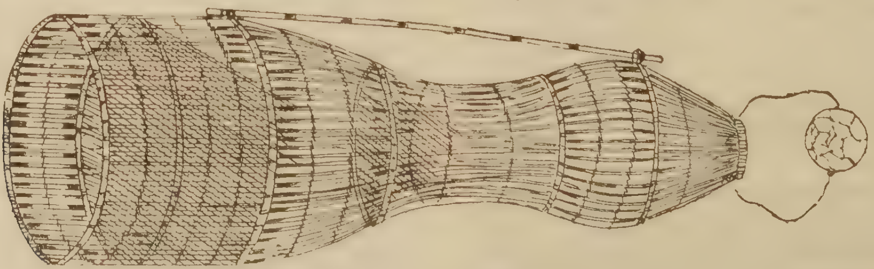

FIG. 3. Filter Trap (Bubu djarang)

terial : Same as above.

eration : Also used in ditches, fixed to stakes f coconut palm and with the opening against he current. Daily yield: 0.75 to 2 kg. of rawns and small fishes.

ou biasa—common fyke

cription : A smaller type of fyke.

ngth 60 cm. front diameter 15 cm. and almost ointed at the end.

terial : Same as above.

eration : This fyke can be used everywhere on hallow places, piled up with soil or within lykes. It is mostly used during the night and he yield ranges between ½ and 1 kg. per fyke er night.

ou tadah—filter trap

cription : Bigger than the preceding fyke.

ngth 1.50 m.; front diameter 0.50 m.; rear .15 m.

e trap is placed behind an opening of a ectangular compartment at the angle of a V shaped wing; this compartment can be raised or lowered. At places far from the shore, where the traps are small, this compartment is fixed to the poles of the wings, so that it can not be lifted. To attach the trap to it one has to dive.

The wings are 4-8 m. long (at places far from the shore) and 15-30 m. (near the shore).

Material : As for the others. Wings are made of bamboo poles 4 m. in length.

Operation : This trap is used in rivers where the current is strong and placed with the opening against the flow and 1½ to 2½ m. beneath the surface of the water. This trap is placed about 1 m. above the bottom. Operated at night only. Can be used in series of six to nine. The catch is taken out early in the morning. The average yield per night is about 1 to 3 kg. with a maximum of about 7 kg.

Bubu pantong—filter trap—(Fig. 4)

Description : This large trap 2 m. long is conical anteriorly and spherical posteriorly. At the conjunction between these two parts is situated a single non-return device.

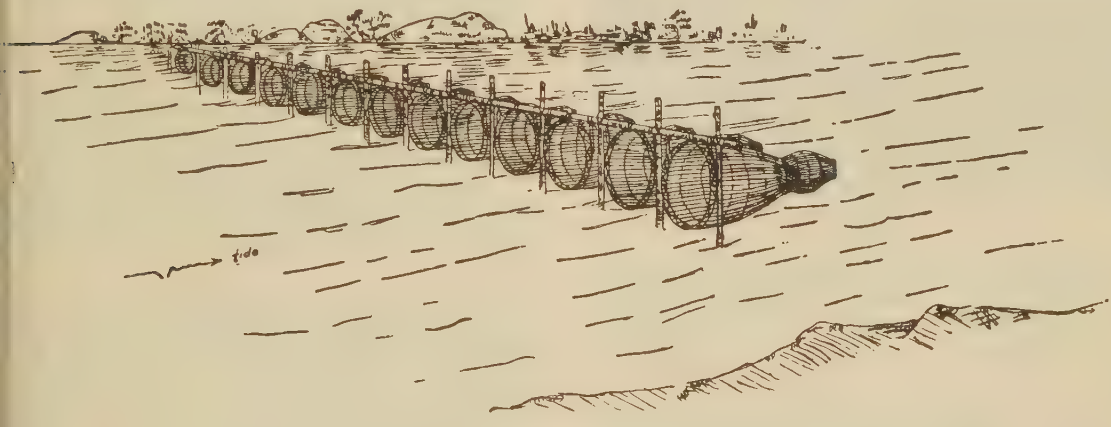
tide
4
Fig ~~5~~ Bubu Pantong (Filter trap)

FIG. 4. Bubu Pantong (Filter Trap)

diameter of the anterior end is 1.3-1.4 m. d that of the posterior one 10 cm. This trap in fact a modification of the preceding ones, it is operated in series and without wings or reens. The traps are horizontally tied etween bamboo poles planted in the river ottom and strengthened by cross-beams.

Material : Bamboo. Stakes and poles are made of bamboo and the cross-beams of stems of the betel-nut palm. (*Areca catechu*).

Operation : This trap is also operated at night only. The traps are attached to the poles early in the evening at the flood tide. A series of traps may be operated by a single person or collectively by several persons. The yield is about the same as that of the preceding gear.

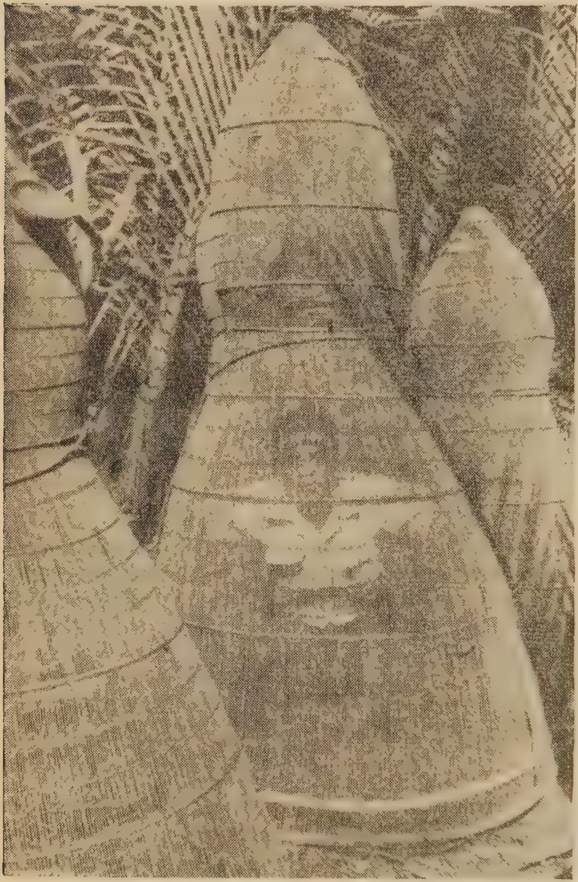

FIG. 4a. Large Bubu Pantong.

Bubu wide—bamboo-screen trap

Description : The material needed consists of several bamboo screens, 5 m. long and 2½ to 3 m. high.

Material : Bamboo.

Operation : During high tide a series of bamboo screens with or without traps, are placed encircling a tidal flat or enclosing a lagoon or river-mouth, so that prawns and fishes are screened out during the ebb.

Antjo, brandjang, djodang—lever net

Antjo, brandjang, djodang—lever net

Description : All three are of the same type and differ from each other only in size. They are square nets which can be lifted by means of a bamboo lever, similar to the so-called ' Chinese lift-net ' encountered throughout the I Pacific Region. *Antjo* is the smallest (2.5 × 2.5 m.) and is operated in ditches marshes; *Brandjang* is of medium size (3 × 3 while *Djodang* is the largest (4 × 4 m.) an operated in river mouths and in coastal wa

The mesh of all three is the same (15 m Usually this type of gear is provided with g barriers.

Material : The net is made of cotton y Cross sticks and lever are of bamboo.

Operation : The net is operated from a fi structure and is raised or lowered by mean the rope attached to the bamboo lever. net is lifted every 10-15 minutes. In Bengawan, Bodo and Derpaju river the y consists for the greater part (90%) of pra but in the marshes of small fishes.

Character of the Fishing Industry in Kroya

The fishing industry in the Kroya district not been set up on a commercial basis and is larg a subsidiary occupation.

As mentioned before the prawn fishing grou are situated in the middle of a rice cultivating a and most of the population outside in the tow therefore consists of farmers.

This area has a very dense population a consequently the average land holding is so sm that there is during the greater of the year no w to be done in agriculture and people are more or l forced to go out fishing, although in periods of r cultivation the farmers and their families are fu occupied with agriculture during the day time, a fishing activities slacken or are carried out at ni only.

Hence, professional fishermen constitute o 7½% of the entire fishing group. For the r fishing is a subsidiary occupation. Professio fishermen are mostly those who do not possess piece of farmland and are not willing or not able choose another profession.

Marketing :

There is in Kroya no special market for pra and fish, which are sold in the general markets.

Several middlemen usually intervene betw fishermen and consumers. The prawns are s by the fishermen to the collectors in their respect villages, early in the morning or in the afterno In the latter case the prawns are then steamed t same evening and will be sold at the market t following day.

middlemen buy the prawns from the fisher-
units of tins containing 4-5 kg. at the price of
5 to Rp. 20 per tin, and carry them to the
ts of the nearby towns by bicycle, cart or by
means of conveyance.

he markets, the prawns are bought by retailers,
n turn sell them to consumers, either in the
condition or after being prepared as *rempejek*
ers made of rice flour with some prawns).

s usual for consumers to bargain with the
rs. Big Palaemon are sold by piece and the
r prawns by heaps. The most expensive
is *Palaemon carcinus*, which in the beginning
5 fetched a price of Rp. 7 to Rp. 9—per kg.
rice of other species varied between Rp. 5
Rp. 6. There is hardly any difference in
between fresh prawns and boiled or dried ones,
gh fresh ones tend to be slightly more
sive.

prawn cracker producers, who peddle their
odities at the Kroya railway station form an
ant group of permanent buyers.

wledgement

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9

SHRIMPS OF THE SETO INLAND SEA OF JAPAN

by

J. Yasuda*

The Seto Inland Sea is the largest inland sea in Japan, surrounded both in the north and the east by the south-western part of the main island of Japan, in the south by the northern part of Shikoku and in the west by the north-eastern part of Kyushu. It is connected with the Pacific Ocean through the Kii Channel in the east and the Bungo Channel in west. The total area amounts to about eight thousand square kilometres.

For convenience, this sea can be demarcated eight fishing grounds (Fig. 1) from which specim were obtained for this study.

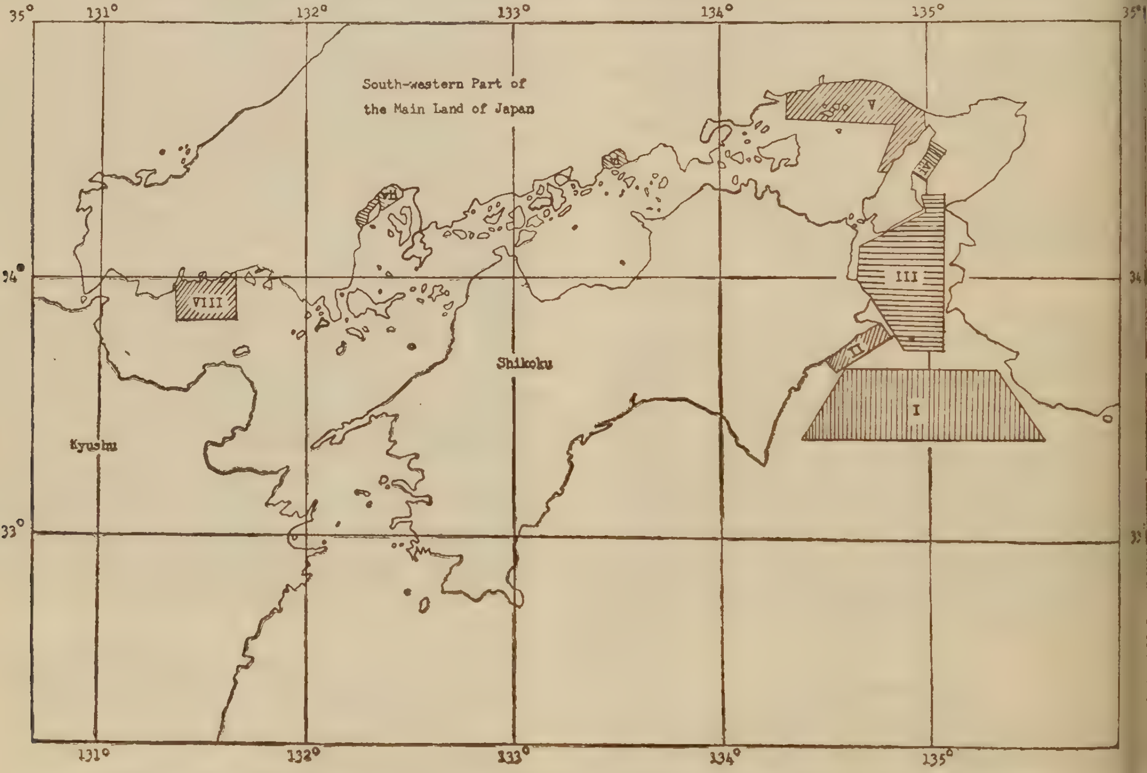

Fig. 1. The fishing grounds in the sea of the south-western part of the mainland of Japan

The conditions of these eight fishing grounds are given in Table I.

Fifty-four species of shrimps have been known from the Seto Inland Sea and twenty-six of them are considered to be of economic importance.

Generally, the kind and composition of animals and plants are different at the different grounds, according to their distance from the ocean. This is reflected also in the nature of the shrimp catches as shown in Table 2, and they probably do not migrate very extensively between these grounds. shrimps which inhabit the deep, open sea (grou I) are quite different from those in other in fishing grounds (grounds II-VIII). In ground besides the two species *Metapenaeopsis coniger* *M. latus*, there are four other species which are found in ground III. It is characteristic that principal ten species which are found commo inside the Seto Inland Sea (grounds IV-VII), not caught from grounds I and II. On the ot hand, all of these ten species are found in grou here seven other species also occur. Four of seven species are present also in ground II, one, *Plesionika* sp., is present in ground IV . This species is also collected from ground Thus *Plesionika* sp. has a wide distribution, ing both in the inner and outer areas of the land Sea.

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* Inland Sea Regional Fisheries Research Laboratory, Ujina-machi, Hiroshima-shi, Hiroshima Ken, Japan.

osition of the Shrimp Catches

he Seto Inland Sea the three species, *Meta- psis barbatus*, *Trachypenaeus curvirostris* *etapenaeopsis acclivis* are more abundant her species of shrimp (Table III). The follow- cies are seen to predominate in the respective ls : *Penaeus japonicus*, *Metapenaeopsis barbatus* *typopenaeus compressipes* in the marginal (grounds III, IV, V and VIII), *Metapenae- clives*, *Metapenaeus monoceros*, *Parapaeneopsis* in the central regions (grounds VI and VII) *ago affinis* in the secondary inland bay (ground Though the causes have not yet been fully l, it may be surmised that differences in the conditions, such as velocity of the sea current, of the sea bottom, depth, salinity and other es of the sea water etc., may be responsible.

vity and Migration :

le the life-history of the main shrimps living Seto Inland Sea has been studied, that of nd sub-deep sea shrimps is scarcely known.

shrimps found in the Inland Sea as a rule live year, with the exception of *Penaeus japonicus*, gevity of which is believed to be more than ars. However, most of those caught are one year (Table IV).

rding the longevity of the deep sea shrimps, *us nipponensis*, Tamura (1950) reported it was s. On the other hand, Kubo (1951) was ul of Tamur's surmise and believed that it o years in the case at least of one species, *us kessler* Czerniavski.

. Pike (1954) has pointed out that the longevity deep sea shrimp Species, *Spirontocaris gii* is more than two years. There appear nore species with longer lives among the deep imp than among the inland sea ones.

the cases of *Metapenaeopsis acclivis* and *penaeus curvirostris* which are found most ntly in the Seto Inland Sea, the young thrive numbers in a certain inland bay of the Seto Sea (Ground VI), but most of them migrate s the mouth or even outside the bay, as they That is to say, the habitats of the young adult are different. But in the part of the side the bays, that is, in the Inland Sea proper, the young shrimps have a tendency to crowd in the coastal waters, but they do appear everywhere from coastal waters to deeper areas. However, no definite pattern of migration is observed.

Juveniles of *Penaeus japonicus* are collected from near the beach throughout the year. The length of their carapace ranges from 2 mm to 45 mm, the largest number being under 32 mm. Younger stages with carapace of 2 mm. and under are planktonic. Beyond that size they turn benthic and occur only near the beach.

The shrimps grow to medium size from June to October and move from the beach to the off-shore where they are fished in large quantities. For example, the size of the shrimp collected from a certain beach in late September was from 4 to 23 mm. in carapace length, and the size of those fished from an off-shore area was from 22 to 48 mm. Moreover, the larger sized shrimps are found at the deeper level for the same beach, and the shrimps migrate first from shallower to deeper water and then from the lower level to the off-shore regions, as they grow.

Penaeus semisulcatus spends its younger life (from late August to middle of October) in the definite sea region where *Zostera marina* are growing, when the carapace length is from 3.2 mm. to 17 mm. (in the bay of ground VI). After the middle of October, none of them can be found there, whereas they are fished in the off-shore areas with muddy bottom.

The young of both the species *Metapenaeus affinis* and *M. joyneri*, as in the case of *Penaeus japonicus* mentioned above, are collected abundantly at the beach, and none of the large sized specimens are obtained there. While the young shrimps cannot be caught in other regions of the sea, it may be recognized that these two kinds of shrimps also migrate as they grow.

The investigations on the ecology of the young of *Metapenaeus monoceros* collected from the Seto Inland Sea are not adequate, but there may not be much difference in their ecology from that of the Chukai (an inlet of western part of the main island of Japan, which opens to Japan Sea), where they spend their younger stage in the coastal waters from August to November and then migrate off-shore from October to November.

The migration of the main species of shrimps having been mentioned above, the shrimp genera appear to fall into two different groups, as follows :

(1) The young and the adults live together at the same place without any marked migration . . . . . . *Trachypenaeus* (*T. curvirostris*),

Metapenaeopsis (*M. barbatus*, *M. acclivis*), *Crago* (*C. affinis*).

(2) The young and the adults live separately, being found in different places, the young spending their life in definite regions, especially in brackish waters near the shore, moving to the off-shore regions when they are grown ...... *Penaeus* (*P. japonicus*, *P. semisulcatus*) *Metapenaeus* *M. joyneri*, *M. affinis*, *M. monoceros*.)

Of these two types, the former is comparatively small, while the latter is large, being praised as ' high class shrimp '.

Growth of the Shrimps :

Two different types of growth (A type and B type) are distinguished in the shrimps found in the Seto Inland Sea, and beside these, a mixed type A-B type) is also seen. They are as follows :

A-type : The young shrimps grow continuously and rapidly to adult size, then grow at a much reduced rate until the next spawning season. The four species, *Penaeus semisulcatus*, *Metapenaeus monoceros*, *M. joyneri* and *M. acclivis* are of this type.

B-type : The young shrimps do not grow for a limited period and thereafter grow very rapidly before the spawning season. The four species, *Metapenaeus affinis*, *Metapenaeopsis barbatus*, *Parapeneopsis tenellus* and *Crago affinis* belong to this type.

A-B-type : The period of appearance of the young shrimps in this case is very long and the young shrimps which appear at the earlier part of the period are of A-type and those at the latter part are of B-type. The two species *Penaeus japonicus*, *Atypopenaeus compressipes*, and *Trachypenaeus curvirostris*, belong to this type (Table V).

The period of occurrence of young shrimps being comparatively shorter in the case of A-type, the fishing rate of the young shrimps is small; on the contrary, it being longer in the case of B-type, the fishing rate of the young shrimp in this case is large. It is essential to know the place represented on the growth curve of the particular shrimps being fished.

Appearance of the Shrimps :

It may be presumed that the amount of shrimps caught each month in an area such as the Seto Inland Sea, where fishing effort is intensive, represents the amount of the existing shrimp population. But it is possible that a portion of the population may escape capture by hiding in the bottom during their resting phase. The amounts of catch of the different shrimps are shown in Figures 2a and in which two summits are generally found in respective curves. The first summit shows heavy increase of body weight of the individ shrimp before the spawning season, and the seco one shows the rapid increase of the number of o-a group. The remarkable decrease in the catches many kinds of shrimps during winter has be indicated before. With the onset of spring, t catches are seen to improve. While the pe periods of some species occur at the same time, others the peaks occur alternately.

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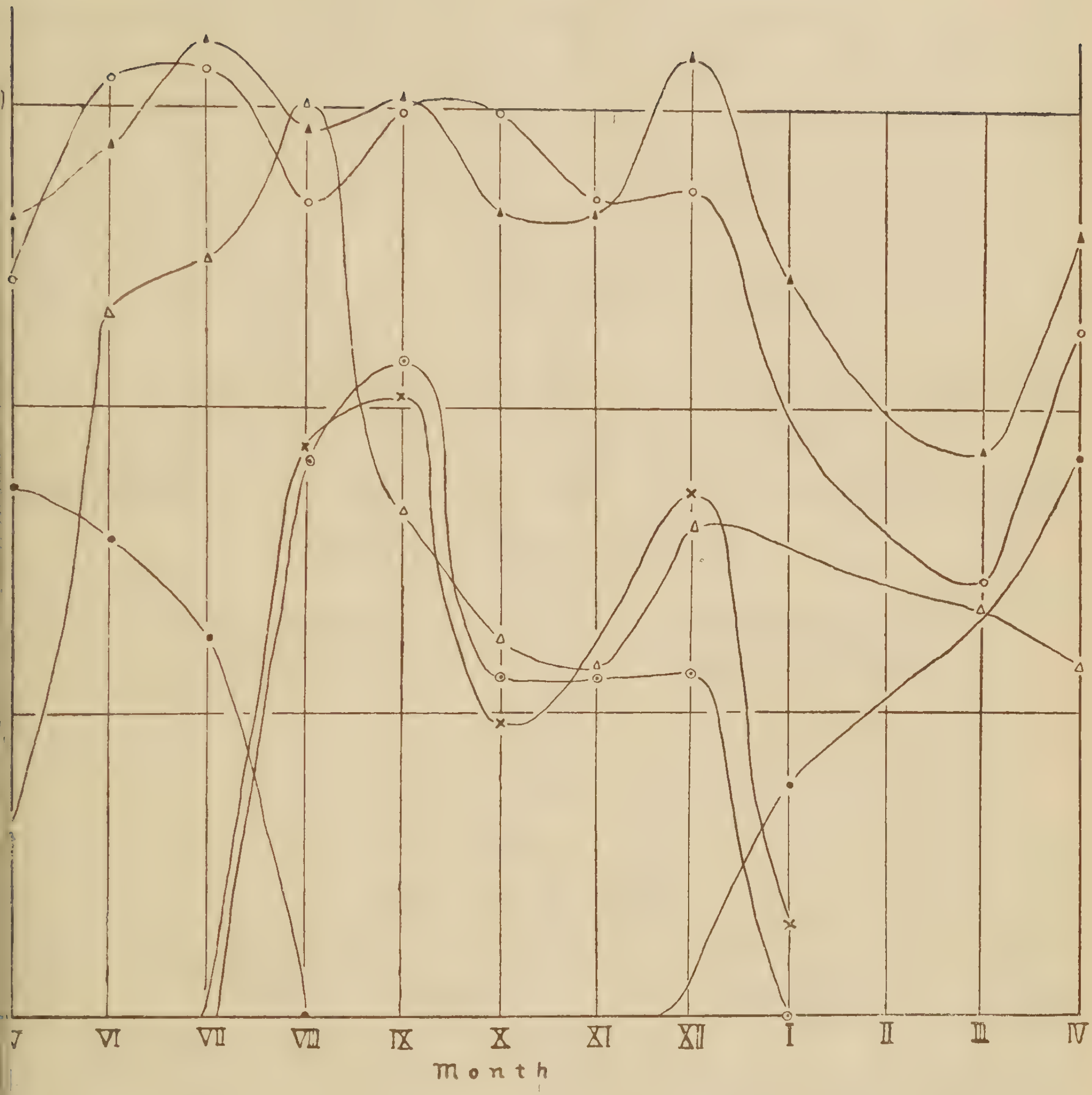

Fig. 2a. Appearance curve of chief shrimps

—▲— *Metapenaeopsis acclivis*
—○— *Trachypenaeus curvirostris*
—△— *Metapenaeopsis barbatus*
—●— *Crago affinis*
—×— *Parapenaeopsis tenellus*
—⊙— *Atypopenaeus compressipes*

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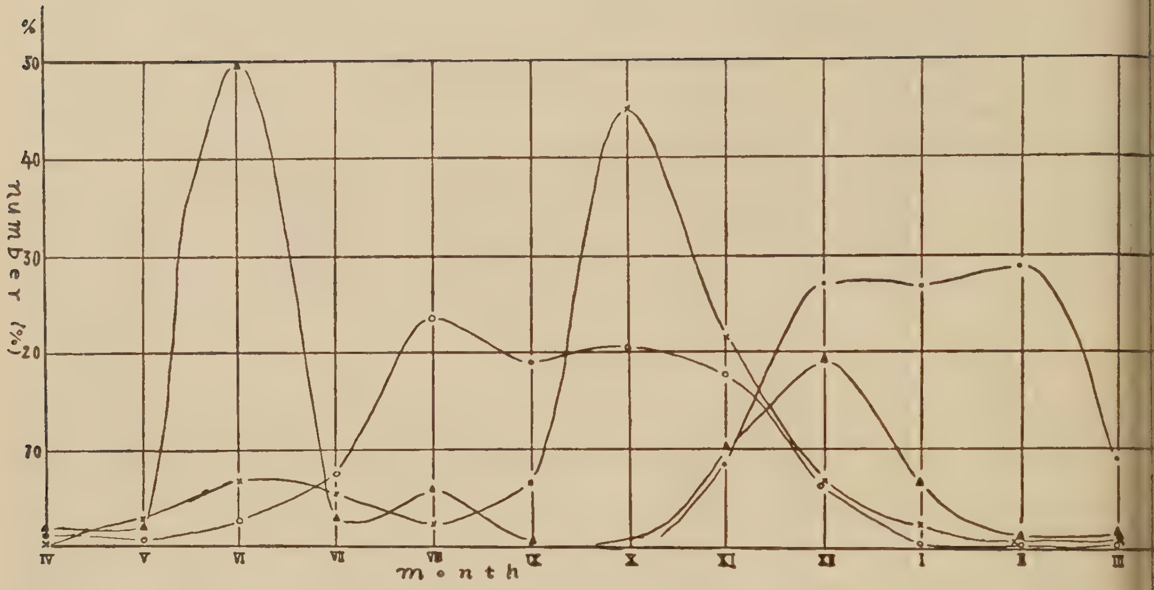

Fig. 2b. Appearance curve of chief shrimps

TABLE I

Conditions of fishing grounds

No.	Fishing Ground	Depth (m.)	Water Temperature (Bottom)°C		Chlorinity (Bottom)%o	
			June	December	June	Decem
I.	Deep Sea (Outside of Kii Channel) ..	100-500	20.0	18.5	19.0	19.
II.	Coast of Hiwasa	40-70	19.5	18.0	18.8	18.
III.	Kii Channel	50-70	19.3	18.0	18.8	18.
IV.	Osaka Bay (Coast of Awaji)	20-50	18.8	17.0	18.0	18.
V.	Harima-nada	15-30	18.0	15.8	17.8	17.
VI.	Kasaoka Bay	5-15	16.8	13.0	17.6	17.
VII.	Hiroshima Bay	10-15	16.8	15.4	17.9	17.
VIII.	Suo-nada (Coast of Yamaguchi)	10-20	17.0	16.2	18.1	18.

TABLE II

Distribution of the main shrimps in the Seto Inland Sea

ishing Ground	Suo-nada	Hiroshima Bay	Kasaoka Bay	Harima-nada	Osaka Bay	Kii Channel	Coast of Hiwasa	Deep Sea
Species	VIII	VII	VI	V	IV	III	II	I
japonicus	o	o	o	o	o	o	o	..
ulcatus	o	o	o	o	o	⊙	..	..
eus monoceros	o	o	o	o	o	o	..	..
s ..	o	o	o	o	o	..	..	..
ri ..	o	..	o	o		o	..	..
naeus curvirostris	⊙	⊙	o	⊙	⊙	⊙	..	..
eopsis barbatus		o	o	⊙	⊙	⊙	..	..
is ..	⊙	⊙	⊙	o	o	o	..	..
aeus compressipes	o	o	o	o	o	o	..	..
eopsis tenellus	o	o	o	o	o	o	..	..
inis ..	o	o	o	o	o	o	..	..
eopsis dalei	⊙	..	..	o	o	..	..	..
eopsis lamellatus	..	..	..	o	o	..	..	..
istata	..	..	..	..	..	o	..	..
distincta	..	..	..	..	..	o	o	..
us fissurus	..	..	..	..	..	o	o	..
atus ..	..	..	..	..	..	o	o	..
sp.	o	..	..	..	o	o	o	..
nnata	..	..	..	..	..	o	..	..
us levicarina	..	..	..	..	..	o	..	..
opsis latus	..	..	..	..	..	..	o	..
..	..	..	..	..	..	..	o	..
ibogae	..	..	..	..	..	..	..	o
nartia	..	..	..	..	..	..	..	o
us ensifer	..	..	..	..	..	..	..	o
ipponensis	..	..	..	..	..	..	..	o
japonicus	..	..	..	..	..	..	..	o

Important species as Marine products. o : Collected species. .. : Uncollected species.

TABLE III

Percentage Composition of shrimp catches at different fishing grounds in the Seto Inland Sea

Species of shrimp	Kii channel	Osaka-bay Harima-sea	In and out Kasaoka-bay	Hiroshima Bay	Suo-sea
	III	IV	VI	VII	VIII
	%	%	%	%	%
Penaeus japonicus	7.4	3.1	1.2	2.1	8.9
P. semisulcatus	1.2	0.2	2.2	0.4	0.1
Metapenaeus monoceros	..	3.3	13.1	5.3	0.1
M. affinis	0.2	0.1		1.6	
M. joyneri		2.3			5.1
Trachypenaeus curvirostris	6.0	36.0	2.7	14.4	32.9
Metapenaeopsis acclivis	15.6	17.3	25.3	71.0	33.6
M. barbatus	29.2	28.8	1.5	1.6	12.7
Atypopenaeus compressipes	8.6	0.5			1.0
Parapenaeopsis tenellus	2.6	0.3	8.2	0.5	0.5
Crago affinis	1.1	3.3	45.3	2.3	5.1
Metapenaeopsis lamellatus		1.5			
Parapenaeopsis cornutus	0.4				
Crangon sp.	4.9		0.5	0.8	
Haliporus sibogae	6.1				
Parapenaeus	0.4				
Plesionika sp.	15.4	3.3			
Aegeon pennata	0.9				

TABLE IV

Age and spawning season of the shrimps found in the Seto Inland Sea

Species of shrimp	Age	Spawning season	Remarks
	Year		
Penaeus japonicus	2	June — Oct.	Fujinaga
P. semisulcatus	1		
Metapenaeus monoceros	1	July — Aug. (Best season)	Ota
M. affinis	1	Aug. — Oct.	
M. joyneri	1	June — Aug.	Yatsuyanag
Trachypenaeopsis curvirostris	1	June — Sept. o	
Metapenaeopsis acclivis	1	June — Sept. o	
M. barbatus	1	July — Aug.	
Atypopenaeus compressipes	1	Last of June — July o Last of Aug. — Oct.	
Parapenaeopsis tenellus	1	Middle of July — Sept. o	
Crago affinis	month 1, 5 — 7	Apr. Nov. — May o	
Pandalus nipponensis	4 years		Tamura

o = species which have the span of life shorter than a year and two or more generations.

TABLE V-A.

Time of appearance of young shrimps and period of good growth derived from the growth curve

ies of mp	Growth Type	Time of appearance of young	Period of good growth		Max. size		Remarks
			Term	Size	Size	Term	
aponicus	A.B.	Last of July	Last of July—Last of October				Carapace length
lcatus	A	Beginning of September					ditto
eus *ros*	A	Middle of October	June—Middle of September	mm. mm. 24-31	35	Last of October	ditto
				21-24	26	ditto	
	B	Beginning of October	Middle of May—Last of June	11-20	25	Last of August	ditto
				10-15	17	ditto	
i	A	Last of July	Middle of August—Last of October	10-26	33	Last of August	ditto
				10-24	26	ditto	
aeopsis *tris*	A.B.	Last of August	August—Last of October	6-13	20	Last of August	ditto
				6-12	18	ditto	
eopsis	A	Last of August	Last of August—Beginning of October	11-14	18	Beginning of August	ditto
				10.5-12.5	15	Middle of August	
us	B	Beginning of August	Last of May—Last of July	9.5-17.5	18	Beginning of August	ditto
neus *sipes*	A	Last of August	Beginning of Sept.—Last of November	5-12	15	Last of June	ditto
				4.5-7	10	ditto	
opsis	B	Beginning of August	Last of May—Middle of July	7-15	16	Last of July	ditto
				7-11	11	Middle of July	
nis	B	Last of May	Beginning of November—Last of January	20-41	48	Last of March	Body length
				18-32	35	ditto	

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TABLE V-B

Size range of shrimp

Species of shrimp	Sampling term	Size of shrimp		Month sampled Max. and Min. size		Remark
		Min.	Max.	Min.	Max.	
		mm.	mm.			
Metapenaeopsis lamellatus	December	8	12			Carapa length
Solenocrae distincta	Sept.-Dec.	10	33	December	October	„
Parapenaeus sp.	Oct.-Dec.	13	28	October	December	„
Pandalus sp.	December	8	18			„
Aegeon pennata	December	10	12			„
Metapenaeus latus	Oct.-Feb.	8	19	February	December	„
M. coniger	Oct.-Jan.	12	18	October	December	„
Haliporus sibogae	March	2g.	12g.			Body weigh

TABLE VI

Shrimp production in Seto Inland Sea

Species of shrimp	Weight Kan*	%
Penaeus japonicus	239,368	5.04
P. monodon	8,984	0.19
Metapenaeus monoceros	67,797	1.43
M. affinis	8,942	0.19
M. joyneri	106,210	2.24
Trachypenaeopsis curvirostris	1,354,250	28.52
Metapenaeopsis acclivis	1,519,600	31.98
M. barbatus	897,331	18.89
Atypopenaeus compressipes	90,290	1.90
Parapenaeopsis tenellus	66,681	1.40
Crago affinis	185,880	3.91
Metapenaeopsis lamellatus	20,850	0.44
Cragon sp.	41,080	0.87
Solenocera distincta	25,600	0.54
Parapenaeus sp.	1,550	0.02
Plesionika sp.	111,100	2.34
Aegeon pennata	3,870	0.08
Parapenaeopsis cornutus	1,550	0.02
Total ..	4,751,933	100.0

* 1 kan = 8.32 pound.

10

REVIEW OF THE BIOLOGY AND SYSTEMATICS OF SHRIMPS AND PRAWNS OF JAPAN

by

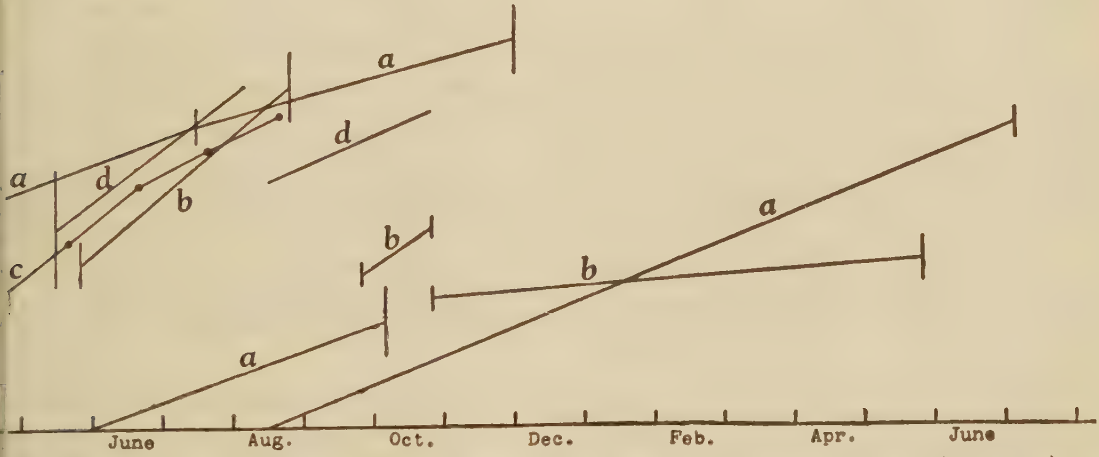
I. Kubo*

PART I. BIOLOGY

wth

ill be seen from the list of references d, much work has been done by Japanese on the growth of warm-water shrimps and

ards the growth of *Penaeus japonicus* Bate, t important commercial prawn in Japan, observed the growth of the prawn cultured and fed with silk-worm pupae. Kajiyama this prawn in the Inland Sea of Japan. Hudinaga's investigation was made on the growth of zoea and mysis of the animal in connection with early development. Utsunomiya *et al* observed the growth of the prawn appearing in brackish water regions of the Inland Sea of Japan. The present author, made a scrutiny on the mass-growth of the prawn of the Tokyo Bay by means of an analysis of size-frequency distribution dealing with the material taken monthly by a fisherman's prawn-net at Hatazawa. Yatsuyanagi and Maekawa made a similar study on material taken monthly during a year from Ogori inlet of the Inland Sea.



. 1. Average growth of *Penaeus japonicus*, based on the data of Kajiyama (a), Kubo (b), Seno (c), and miya *et al.* (d). Abscissa, months; ordinate, body-length or total length (in d only) in cm. Vertical bars range of body-length or total-length.

ma states that the larvae hatched out during g and early summer attain a body length of excluding rostrum in early autumn, and rn in summer reach lengths of 12.1 cm. in and 13.6 cm. in the female by late June of year. Most of them are likely to measure cm. in the late fall, when they die. Accord- sunomiya *et al*, the prawn appears in May brackishwater regions of the Yamaguchi e coasts of the Inland Sea with a total length cm. and grows to about 14.5 cm. long by early August. New broods about 10.5 cm. in overall length occur in August. These measure about 13.5 cm. in late October.

The animals used in Seno's experiment having a body length of 4.2 cm. were put into the ponds on April 2. They were measured on the 19th of every month from April to August and grew to 5.6, 7.9, 10.3, 11.8, 13.3 cm. in the respective months. According to the present writer's investigation based on the material obtained from Hatazawa, the body length ranges from 5 to 12 cm. in late May in both

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fessor, University of Fisheries, Tokyo, Japan.

sexes, the modal length being 6-7 cm. in the male, and 7-8 cm. in the female. In late August the males measure 10-16 cm. long, with a modal length of 13-14 cm. and the females 12-18 cm. with modal length 15-16 cm. Juveniles appear in late September when the range of body length falls to 4-13 cm. and the mode to 6-7 cm. This new generation is seen grown with body length range of 4 to 14 cm. and two modes with peaks at 5-6 cm. and 8-9 cm in both sexes. Other material, obtained from a sandy beach lying between high and low tide-marks of Chiba City (Tokyo Bay) on March 25 and April 25 of 1955 has a body length range of 4.2 to 5.8 cm. (average 4.9 cm.) and 4.6-8.3 cm. (average 5.7 cm.) respectively. These young prawns are no doubt produced in the late spawning season of the previo year.

Yatsuyanagi and Maekawa's investigations on th growth of this prawn show that the modes of th body lengths are different for the spring and summ spawning seasons. This is shown in Figure The spring broods have by early autumn attained length of 4.5-5.0 cm. and 4.0-4.5 cm. in carapac length, 13.7-15.3 cm. and 12.2-13.7 cm. in body lengt for females and males respectively. These brood in autumn go out to sea from the inlet where the hatched and pass into hibernation, little grow taking place during the winter season. They spaw in the late spring of the following year after som growth. It is supposed that after this they die

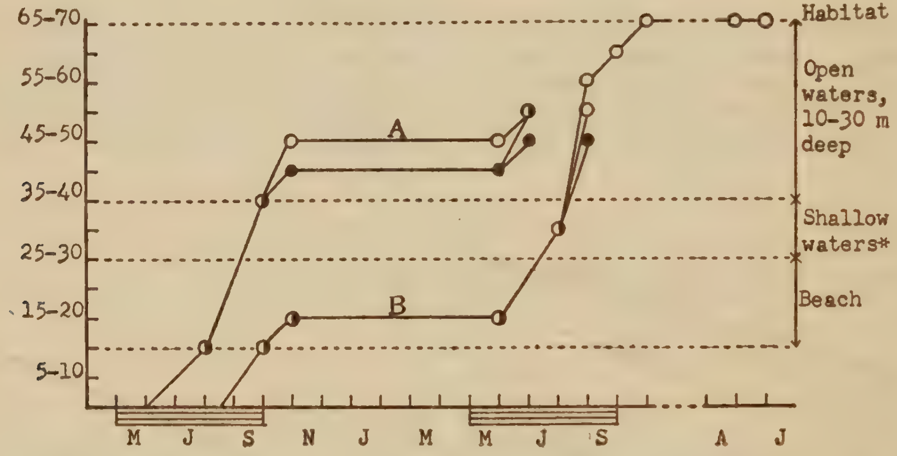

FIG. 2. Schematized diagram of the growth of Spring- (A) and Summer- (B) broods of *Penaeus japonicus* in relation to some ecological matters. Horizontal axis, months; vertical axis, carapacial length in mm. ○, female; ●, male. *, shallow waters less than 10 m in depth. Striped area showing spawning season. (After YATSUYANAGI and MAEKAWA, 1955, somewhat modified).

Meanwhile the summer broods grow to a length of 1.5-2.0 cm. carapace length (4.5-6.2 cm. body length)* in both sexes by the autumn of the same year. This group passes the winter in shallow waters near the beach and does not grow. It goes out towards open waters during the spring of the next year. During mid and late summer it seems that they grow very rapidly to some 4.5-5.0 cm. in carapace length (13.7-15.5 cm. in body length) in the male and 5.0-6.0 cm. in carapace length (15.5-18.5 cm. in body length) in the female, when they reproduce. Curiously, some females appear to survive until the spring of their third year, when they measure as much as 6.5-7.0 cm. in carapace length (20.1-21.6 cm. in body length).

The growth rate set forth by Kajiyama, Kubo, and Utsunomiya *et al* is largely in agreement with the above, and also coincides with that of the summer broods given by Yatsuyanagi and Maekawa (195 It does not, however, agree with that shown Yatsuyanagi and Maekawa for the spring broo The average rate of mass growth of this prawn given in Table I.

It should be noticed that the growth rate obser by Seno (1910) for the prawn cultured in a pond fro April to August tallies with that for the summ broods. Also, the body lengths of prawns take from Chiba city beach in March and April agr fairly well with those occurring on a sandy bea exposed at low tide on the Ogôri inlet, Yamaguc Prefecture.

Kishinouye states that *Penaeus orientalis* has length of about 60, 91, and 151 mm. in July, ea August and mid-September respectively. Similar

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* Relationship between carapace length (L_1) and body length (L_2): $L_2 = 3.07 L_1 - 1.5$

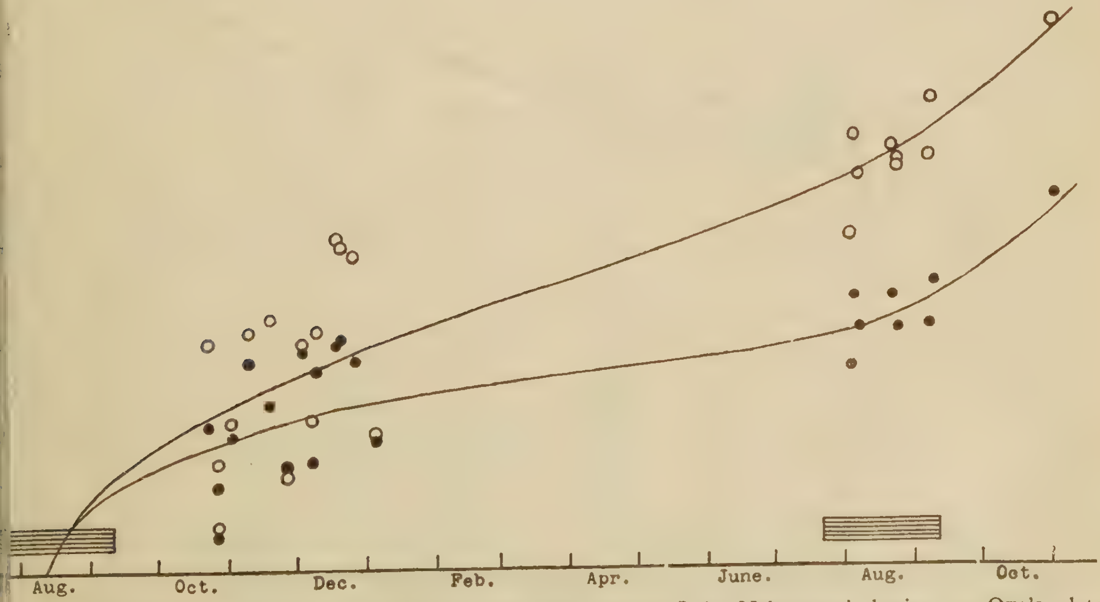
TABLE I

Average mass growth of *Penaeus japonicus* (the first figure is body length in mm., carapace length in parentheses).

Season Broods	Summer	Early autumn	Late spring of 2nd year	Summer of 2nd year
Spring broods	30-45, ♀♂ (10-15), ♀♂	137-153, ♀ 122-137, ♂ (45-50), ♀ (40-45), ♂	153-169, ♀ 137-169, ♂ (50-55), ♀ (45-55), ♂	
Summer broods		45-61, ♀♂ (15-20), ♀♂		91-108, ♀♂ (30-35), ♀♂

Season Broods	Late summer of 2nd year	Autumn of 2nd year	Spring of 3rd year
Spring broods			
Summer broods	153-185, ♀ 153-169, ♂ (50-60), ♀ (50-55), ♂	185-216,♀ (60-70),♀	185-216, ♀ (60-70), ♀

(1949) reports this species to be about 60 late July and 150 mm. in late August in rom tip of rostrum to distal end of telson. is only one contribution available regarding th of *Penaeus monodon*, an important species warmer seas by Nakano. His experiments were made at Taiwan, Formosa. In one of his experiments, the prawn grew to 2.6-3.15 cm. (2.82 cm. on average of 10 individuals) from 1.25-1.50 (1.39) cm. during 26 days (from May 8 to June 2), with a water temperature of 19-29°C. The prawn was fed once a day on the meat of an atyid shrimp,



3. Showing the growth of *Metapenaeus monoceros* in the Lake Nakanoumi, basing on OTA's data. a, months; ordinate, carapace-length in mm. ○ female; ● male. Striped area showing spawning

Neocaridina denticulata, oyster, and small fishes. In another experiment he cultured the prawn in a pond together with *Chanos chanos*, feeding it with sardine meat during 182 days from May 9 to November 7. The water temperature at that period was from 29.0-35.4°C. In this case the prawn increased in body length from 3.3 cm. to 11.67 cm.; twenty individuals out of about a thousand having been picked out at random for measuring, were kept together.

On *Metapenaeus monoceros* (Fabr.) Ota gathered material from various localities from lake Nakanoumi, a salt lake lying on the Japan Sea coast of Shimane Prefecture in the months from August to January. As shown in Fig. 3, the prawn spawned from late July to early September, grew to 19-28 mm. and 18-23 mm. in carapace length in December for female and male respectively, and to 27-34 mm. (female) and 21.5-25.5 mm. (male) in the spawning season of the next year. In mid-autumn, it had a carapace length of about 37 mm. (female) and mm. (male), after which it presumably dies.

Oshima and Yasuda (1942) studied growth *Metapenaeus burkenroadi* Kubo [*M. affinis* (Milne-Edwards)], on the basis of material con mercially caught from the east coast of Ise Ba According to them, the prawn spawned from m July to late September, attained carapace lengt of 23-26 mm. (female) and 17-19 mm. (male) by th spawning season of the next year, but growth ra is uneven. Very rapid growth may occur at tw periods, the first in the young stage at less than mm. carapace length and the second just befo spawning, when the prawn grows from about 13 mm to about 21 mm. in the female, and from 12 mm. 17 mm. in the male during only a month, in June.

Ikematsu (1955) studied the growth of *Me penaeus joyneri* (Miers) from material taken fr the Ariake Sea, Kyushu, and recorded his data a sigmoid curve as illustrated in Fig. 4. The praw

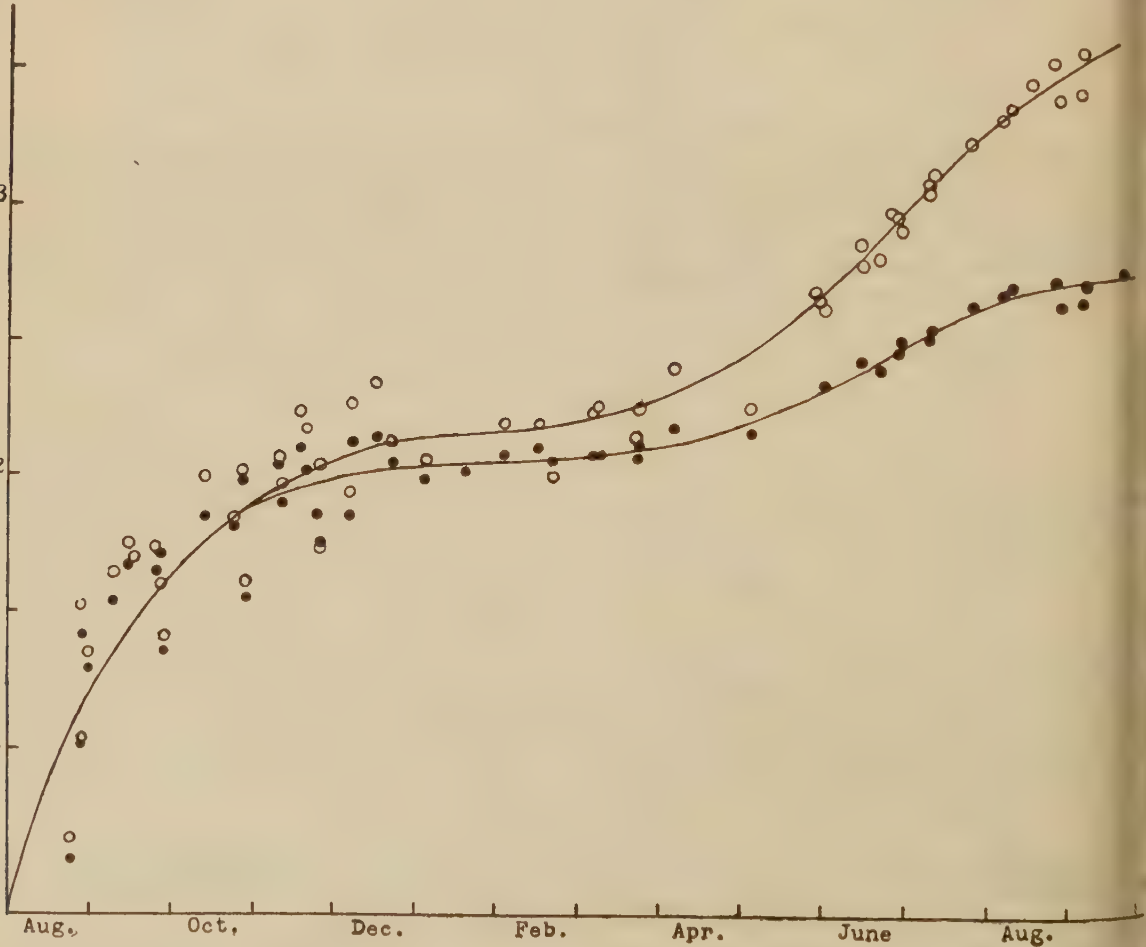


FIG. 4. Growth of *Metapenaeus joyneri* of Ariake Bay, Kyushu. Abscissa, months; ordinate, carapace-length cm. ○ female; ● male. (After IKEMATSU, 1955.)

:ed in summer attains, after rapid growth, a ce length of about 2 cm. (about 8.5 cm. in body)* by the autumn of their first year. There e growth during the winter season, but the again accelerates in spring and summer of econd year, until they reach a carapace length ut 2.8 cm. (11.7 cm. body length) in the male out 3.5 cm. (14.5 cm. body length) in the by the late autumn. As none larger than these been found, it appears that the prawn dies bout this size during the autumn of its second Sexual difference of growth is not found until st autumn, when the animal measures about . in carapace length after which the females aster than the males, the difference becoming lly more apparent until, during the summer ng season, the female is about 20% larger than ale.

reports are available on the growth of *penaeus curvirostris* (Stimpson). These are uda (1950) and Maekawa and others (1953). 's report is based on material taken monthly n June and December from the west coast of Peninsula, Aichi Prefecture. The modes of dy length† as found by him are shown in II.

TABLE II

hly modal body length in cm. of *Trachypenaeus curvirostris* (Stimpson)

nth	♀	♀	♂	♂
	4.4	6.7	3.9	
	5.2	7.0	4.3	
	6.1	7.0	4.5	
er	3.0	6.4	3.6	5.5
	3.7	4.9	3.9	
er	4.4	4.9	3.6	
er	3.7	4.9	3.6	

pears that this shrimp in one year grows to a ngth of about 7 cm. (female) and 5.5 cm. between one year's spawning season and the The breeding season extends from early early October.

awa and others made similar studies of the of the Inland Sea of Japan. Their results appear to coincide with those of Yasuda. Inland Sea, the female of the shrimp reaches length of 3.6-5.8 cm. (average 4.9 cm.) and (7.2) cm. in 9 and 13 months after hatching vely.

regard to the growth of *Metapenaeopsis* Rath.) and *M. barbatus* (D.H.) (=*Parapenaeus akaebi* Rath.), which make up a large part of the commercial shrimp catch of Inland Sea of Japan, an investigation was undertaken by Maekawa and Yatsuyanagi, whose information on the growth of these shrimps is given in Table III.

TABLE III

Growth in females of (*a*) *Metapenaeopsis acclivis* (Rath.) and (*b*) *M. barbatus* (D.H.)

Months after hatching	Body length in cm.	
	(a)	(b)
5	2.6	
8		3.8-5.0
12	4.8-6.8	4.2-6.2
20		5.8-6.2

There are several contributions on the growth of Japanese Palaemonoid shrimps, Kubo (1949a, b, c) having studied *Macrobrachium nipponense* (D. H.), while as regards *Palaemon* (*Palaemon*) *paucidens* De Haan (*Leander paucidens*), a few investigations have been made by Ibaraki Fisheries Experimental Station (1912), Matsui and Wainai (1937), and Saitô and others (1954). Inouye (1949) has studied *Palaemon* (*Palaemon*) *serrifer* (Stimpson) (*Leander serrifer*).

In *Macrobrachium nipponense* of Lake Kasumigaura, the young which is hatched out in the summer months of June and July reaches 9-24 mm. body length with a mode of 15-18 mm. in August, as shown in Table IV and Fig. 5. This population by late autumn has a range of body length from 9 to 33 mm. (mode 18-27 mm. for the female and 21-24

TABLE IV

Monthly mode of body length in mm. of *Macrobrachium nipponense*.

Month	♀	♂
Aug.	15-18	15-18
Sept.	18-24	15-18
Oct.	15-18	15-18
Nov.	24-27	21-24
Dec.	18-21	21-24
Jan.	21-24	21-24
Feb.	18-21	15-18
Mar.	15-18	18-21
Apr.	15-18	15-18
May	30-33	27-30
June	27-30	24-27
July	42-45	24-30
Aug.	42-45	33-36
Sept.	45-48	42-45
Oct.	51-54	48-51

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elationship between body length (L_2) and carapace length (L_3) is $L_2=4.083L_1+0.500$.

onverted from carapace length based on $L_2=3.572L_1+0.175$ in male, $L_2=3.707L_1-0.068$ in female under 14 arapace length and $L_2=3.008L_1+0.9$ in female over the said carapace length.

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mm. for the male). There is little growth in winter, but the modal body length abruptly increases to 27-33 mm. (female) and 24-30 mm. (male) in the spring months of May and June. The shrimp then goes into spawning, and the modal lengths are 42-45 mm. and 24-36 mm. in female and male respectively in July and August, with ranges of 39-51 mm. and 27-39 mm. respectively. Some growth may take place after spawning, the modal body length increasing somewhat 45-48 mm. (female), 42-45 mm. (male) in September, and 51-54 mm. (female), 48-51 (male) in October. This population suddenly becom scarce after November. The diminution in th modal body length during the winter period as see in Table IV, seems to be due to recruitment juveniles.

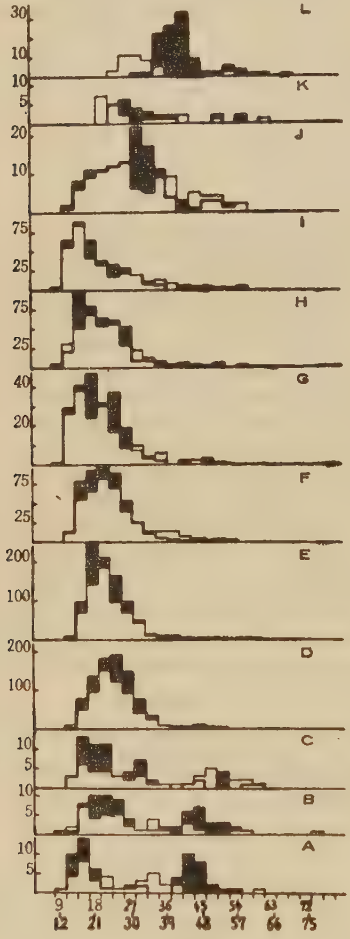

FIG. 5. Monthly size-frequencies of *Macrobrachium nipponense* taken from the Lake Kasumigaura. Abscissa, body-length in mm.; ordinate number of individuals. A-E, months from August to December; F-L, months from January to July. Black, female; white, male.

Concerning the growth of *Palaemon paucide* Ibaraki (1912) reports that this shrimp in the Lak Kasumigaura attains a body length of about 50 an 60 mm. in the female and male respectively durin the first year of life. In the Lake Towada ther appear to be three groups of frequency distributio in material secured in August, and the origin authors have thought the intermediate group with range of 32-52 mm. (mode 42-44 mm.) to represen the growth in one year. These values are muc smaller than those for the shrimp inhabiting the Lak Kasumigaura and this discrepancy appears to present writer to be due to the difference of wate temperature in these lakes, [27.3-30.3°C (28.4° average) in the Lake Kasumigaura, 10-15°C in layer of thermocline of the Lake Towada].

In Hokkaidô, the growth of P. *paucidens* is naturall much slower owing to the lower temperature Handa and others (1930) report that the shrim of the Lake Onuma in the southern part of Hokkai measures 38.7 mm. and 61.4 mm. in body length one and two years. Also the shrimp inhabiting sma natural ponds of Hokkaidô, according to Sait and Yamada (1954), are about 5 mm. in body lengt at hatching and measure 18-20 mm. at one yea irrespective of sex, and 32-34 mm. (female) and 27-2 mm. (male) at two years of age. Remarkably enoug spawning of this shrimp of Hokkaidô takes place the summer of the second year after hatching, instea of in summer of the first year in other parts of Japa

Palaemon serrifer hatched between July an October attains a modal body length of 32-34 mm in the female by September of the following yea The monthly mass growth of this shrimp is show by modal body length in Table V. Rapid growt seems to occur in summer.

TABLE V

Monthly modal body length in mm. of *Palaemon* (*P.*) *serrifer*.

Month	♀	♂
Sept.	20-22	
Oct.	20-22	18-20
Nov.	16-18	14-16
Dec.	20-22	18-20
Jan.	20-24	16-20
Feb.	22-24	18-20
Mar.	20-22	20-22
Apr.	22-24	20-22
May		22-24
Sept.	32-34	

gi (1946) has made an analysis of the mass-
of *Paratya compressa improvisa* Kemp, on the
monthly size frequency distribution. In this
ter shrimp, a large quantity of young be-
to a new age-group appears in September,
h some of these juveniles are already in
e in July. The young population of Sep-
which has a modal body length of 8 mm.
cording to Yokoya, (1922, 1931) be inferred
out in July or August. He states that the
vith a body length of about 3 mm. at hatch-
ch 3.5-3.8 mm. after 11 or 12 days rearing.
opulation reaches a modal body length of
(female) and 17 mm. (male) in late autumn,
is usual, show little growth in winter. In
e modal body length is 25 and 20 mm. in the
and male respectively, fast growth having
l in the spring season. No further notice-
wth appears to take place until August, after
he greater part of the population seems to
r.

2. Longevity

The life of prawns and shrimps is in most cases one year or a little more in warm-water regions while it is several or more years in cold-water zones. For instance, such American warm-water forms as *Penaeus setiferus*, *Crago franciscorum*, and *C. nigricauda* belong to the former category, and such cold-water ones as *Crago vulgaris* of British and German waters, *Pandalus borealis*, *P. kessleri* inhabiting Hokkaidô, and *P. nipponensis*, a deep sea form, are included in the latter.

The average life of the Japanese forms except the two mentioned above is supposed by various investigators to be a year or a little more as shown in Table VI. This inference is made from the analysis of size frequency distributions based on collections at regular intervals. These Japanese species, excluding *Palaemon paucidens* of Hokkaidô, *Pandalus nipponensis* and *P. kessleri*, mostly disappear from the catch soon after they are a year old. Hence,

TABLE VI

Spawning season and average life span of prawns and shrimps.

Species	Spawning season	Average longevity in years
Penaeus japonicus	L5-E9 (L6-L8) (8-10) L5-L9 (M6-M8) (2) 5-9 (6-8) (36)	1 or 2* (8-10,36)
Penaeus orientalis	(7) (39)	1(39) ; Max. 1.5(29)
Penaeus setiferus	E5-L7(33)	1(33)
Metapenaeus monoceros	L5-E9 (8)(26)	1(26)
Metapenaeus joyneri	L7-E9 (7-8)(5)	1 or more(5)
Metapenaeus burkenroadi	M7-L9 (8)(25)	1(25)
Trachypenaeus curvirostris	6-10 (7-8)(20)	1 or 1.5(20)
Metapenaeopsis barbatus	6-9 (7-8)(20)	1 or 1.5(20)
Metapenaeopsis acclivis	8-10 (9)(20)	1 or 1.5(20)
Macrobrachium nipponense	E5-E8(5)	1.3(13, 14)
Palaemon (Palaem.) paucidens	E5-L7(5) ; E6-E8 (1) L3-E10 (38); E5-8(28)	1 (5, 21); 2(1, 28)
Palaemon (Palaem.) serrifer	7-E10(6)	1(6)
Paratya compressa improvisa	4-8 (4-5, 6-8)(31)	1(1)
Crago franciscorum	12-5 or 6(7)	1(7)
Crago nigricauda	4-9(7)	1(7)
Crago vulgaris	summer(19)	3-5*(19) ; 3-4**

small number. The months are numbered and the letters in parentheses indicate prosperous period ; E. early;
mid. **, *Ehrenbaum* (see Lloyd *et al.*, 1947). Max. = maximum.

rage life span may be presumed to be one
a little more. Handa and others give the
of *Palaemon paucidens* of Hokkaidô as two

, it must be admitted that the exact
n life of these crustacea is still unknown,
as a number, are thought to survive after

3. Migrations

Our knowledge of the migrations of shrimps and prawns is still meagre. Only a few accounts exist in respect of some of the penaeids, viz., *Penaeus japonicus*, *P. orientalis*, *Metapenaeus monoceros*, *M. joyneri*, *M. burkenroadi* and a common freshwater form, *Macrobrachium nipponense*. As is generally known, the scale of migration in crustacea generally is not large, and the scope of the species enumerated above is small in most cases. Only that of *Penaeus orientalis*, which supports an important fishery in the Yellow Sea, Korean Bay, and adjacent waters, is somewhat larger in scale. So far as our knowledge is concerned, the migration may be analyzed into the following three types, viz., feeding, spawning, and hibernating migrations.

Penaeus japonicus produced in the Ogôri inlet in spring, according to Yatsuyanagi and Maekawa (1955), go out to open waters until September, and pass the winter offshore at depths of 20 to 30 m., while those born in the same place in the later summer spawning season hibernate off the beaches of the inlet and as has been noted already, begin their offshore migration in the spring of the following year, where they remain until about July. Breeding mainly takes place in waters less than 10 m. in depth. The newly hatched young make their inshore migration for feeding, and live on the beaches until they reach a body length of about 12 cm.

In *Penaeus orientalis*, breeding and hibernating migrations are revealed by Satouchi (1937) and Kasahara (1948). This penaeid passes mid-winter, January and February at depths of about 60 to 80 m. off the west coast of Quelpart Island. The spawning migration occurs from March to May, and the hibernating one from September to December as shown in Fig. 6.

In *Metapenaeus monoceros* inhabiting the salt lake, Nakanoumi, three migrations are recognized by Ota. Adults of this prawn descend for spawni towards the outlet of the lake from July to Septemb The young hatched out in those months migrate August and September to the sandy and muddy are of the upper part of the lake with reduced salinit In the autumn the water temperature falls 23-14°C, and the prawn sets out on its offsho migration in order to enter upon hibernation, whi takes place in the deepest region of soft, mud bottom of the lake.

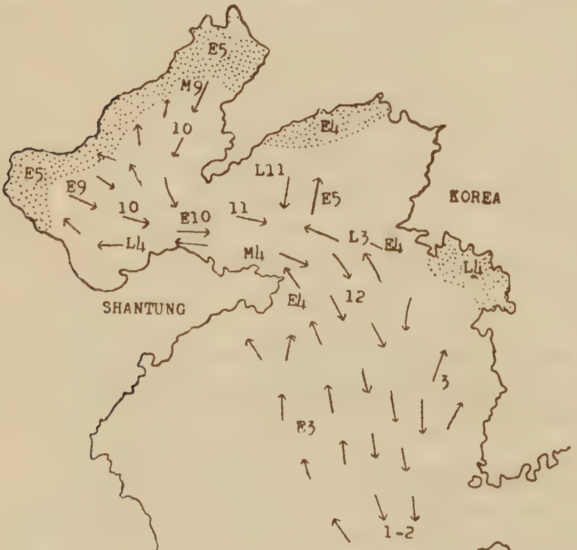

FIG. 6. Showing migrations of *Penaeus orientalis* in Yellow Sea. Figures indicate corresponding months. E, L, and M meaning early, late, and mid respectively. Dotted areas, spawning grounds. (After SATOUCHI, 1937).

According to Yatsuyanagi and Maekawa (1954 juveniles of *Metapenaeus joyneri* are found abundant in shallow waters off Yamaguchi Prefecture in t Inland Sea of Japan during the summer months July and August, disappearing in September, af which they are caught offshore by bottom seines October and November. The haul by these sei is good during the winter season from Decem to March in the deepest areas of the sea Yamaguchi Prefecture. After April, this pra is not, however, taken by such seines, and appea again in shallow waters where it spawns.

It is clear from the above that the hibernati and spawning migrations of this prawn take pl in autumn and spring respectively, but the feedin one is still obscure. In Ariake Bay, such migration of this species seem to be hardly defined. Accor ing to Ikematsu, fishing grounds for this prawn the bay are at about 5 m. depth until November, bu they are at 10 to 15 m. depth during January an February. In the spawning season, between lat May and early September, they are found at depth of 5 to 10 m., the young occurring in August i shallow waters along the beach.

According to Oshima and Yasuda (1942), spawning migration of *Metapenaeus burkenroad* is also known to occur on the east coast of Ise Bay Although the young of this animal inhabit the lo salinity region of the northern part of the coas spawning occurs in southern areas in the summe season.

Macrobrachium nipponense of Lake Kasumiga shows clear feeding and hibernating migration according to Kubo. As shown in Fig. 7, this pra passes the winter season in offshore waters 500-600 m. (Stations III-IV) from the coast, an seems to commence its inshore movement, a fee ing migration, in the spring season as large number shift from Station IV to Station III (Fig. 7, A-E In summer, the population density becomes some what larger in such inshore regions as Stations and II than that existing in offshore waters as Sta tions III and IV (Fig. 7, K-L). As autumn pro gresses, the prawn appears to start on its offshor hibernating migration and the largest number ar found to belong to Station III (Fig. 7, G-I).

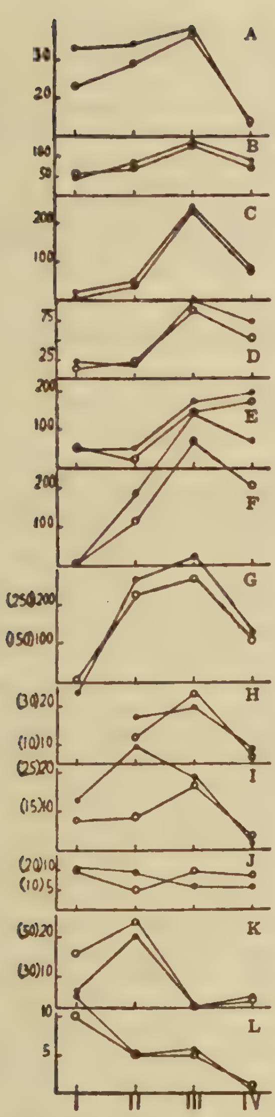

FIG. 7. Showing monthly movement of *Macrobrachium nipponense* in the Lake Kasumigaura. Abscissa, stations from which the material was obtained; the stations, I-IV lying on a straight line running away from shore are set respectively at distances of ca. 30, 400, 500, and 600 m. from the coast of the lake, and are 0.35-0.85, 2.20-2.70, 3.15-3.65, and 3.48-3.98 m. in depth respectively. Ordinate, number of individuals per unit fishing gear; figures given in parentheses are for female. Solid circles, female; soft ones, male. A, May; B, April; C, March; . . . ; K, July; L, June.

4. Food, habital preferences

Studies on the food of prawns and shrimps are scarce, so far as this writer is aware. On that of *Macrobrachium nipponense* and *Palaemon paucidens*, some reports were prepared by the Ibaraki Fisheries Experimental Station (1912). Those of Handa and others (1930) and Matsui and others (1937) are known, while on that of *Pandalus kessleri* only a short account has been set forth by Kubo (1951). As regards the penaeids, only one substantial report has been made on *Metapenaeus joyneri* of Ariake Bay by Ikematsu (1955). The result of an examination of the stomach contents of this prawn is recorded in Table 7, according to which crustacea, bivalvia, gastropoda, and polychaeta may be recognized as the main items of diet of the prawn. The Crustacea ingested are predominantly *Acetes japonicus*, *Neomysis japonica*, and copepoda. Bivalvia, which form a constituent of the food in summer, are mostly the young of *Meretrix lusoria*, *Mactra veneriformis*, and *Venerupis semidecussata*. In gastropoda, *Neverita didyma* larvae, and some belonging to the Cavoliniidae are frequently found. It is well known that *Penaeus japonicus* has a preference for meats of small animals such as fishes, molluscs and crustaceans, and is cannibal as are many other crustacea. In Japan, this prawn is fed under culture conditions with the meat of sardine and *Venerupis semidecussata*. Detritus and decaying organic matter lying on sea bottom are also an important food of the prawn.

TABLE VII

Stomach contents examined on 114 individuals of *Metapenaeus joyneri* (after Ikematsu, 1955).

Animals ingested	% of occurrence	Quantity
Pisces	6.0	little
Crustacea	72.9	many
Gastropoda	10.4	common
Bivalvia	14.2	,,
Polychaeta	8.2	,,
Nematoda	0.7	rare
Echiuroidea	1.5	,,
Ciliophora	1.5	,,
Diatom	71.5	very little

Green algae and other vegetation, diatoms, fishes, fish-eggs, insects, mysis and mud are eaten by *Macrobrachium nipponense* and *Palaemon paucidens* of Lake Kasumigaura as well as by *Palaemon paucidens* of Lakes Towada and Onuma. Fishes, annelids, amphipods, mysis, shrimps, small snails, sponges, ell-grass, algae, diatoms, and so forth have been detected in the stomach of *Pandalus kessleri* of Notsuke Bay, Hokkaidô.

5. Activity

It is generally known that most shrimps and prawns are nocturnal foragers. But only a few reports are available on this subject and based on concrete data. Some observations and experiments were carried out by Mori (1939) on *Palaemon paucidens*, by Kubo on *Macrobrachium nipponense* (1950) and *Panulirus japonicus* (1954), and by Miura and Yamaguchi (1954) on *Penaeus japonicus*. According to Mori, the curves of activity of *Palaemon paucidens* and of intensity of solar illumination show a clearly cut negative correlation irrespective of water temperature. After the sunset the shrimp abruptly became active and the activity continued all night. Just before sunrise, when the solar illumination intensity began to increase, the activity of the shrimp suddenly diminished. Maximum activity at night was between 2 and 5 a.m.

Much larger numbers of *Macrobrachium nipponense* are caught at night as compared with the daytime, according to experiments carried out in Lake Kasumigaura by means of fishermen's set-nets between December to July.

With regard to *Penaeus japonicus*, it has been revealed by Miura and Yamaguchi that this prawn hides under the sand from dawn to twilight, swimming out at night.

In the Japanese spiny lobster Kubo (1954) found a bimodality of its nocturnal activity to exist. The catch of this lobster demonstrates two modes as shown in Fig. 8, one of them occurring during the period from 6 to 8 p.m. and the other from to 4 a.m. on the basis of data obtained by exper ments made with a fisherman's lobster net a Kominato Marine Biological Laboratory of th Tokyo University of Fisheries in May and July As to the factors controlling this phenomenon, a least two basic elements are to be found in the en vironment, and the hunger rhythm of the lobste itself must also be taken into consideration. How ever, no analysis of these aspects has yet been carried out.

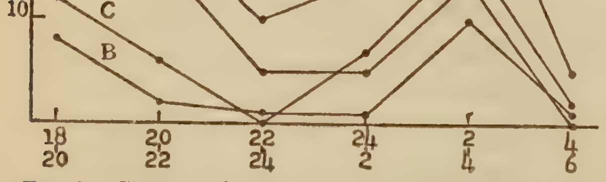

FIG. 8. Change of number of *Panulirus japonicus* (v. SIEBOLD) caught during the catch experiments carried out through night on July 11-12, 1952 (A), May 11-12, '53 (B), July 10-11, '53 (C), and July 24-25, '54 (D) at Kominato. Nets used: 36 units in A, 24 units in B, C, and D. Abscissa, time of day; ordinate, number of individuals.

PART II. SYSTEMATICS

A list of the systematic papers which hav appeared on Shrimps and Prawns in Japan sin World War II is appended.

Kamita has studied the systematics of the fr water Atyidae and Palaemonidae of San-in Provi of Japan, while Kubo has worked on the penae some shore shrimps, palinurids and others. revised monograph on the penaeids (1949) describe 67 species and one subspecies belonging to fou subfamilies and sixteen genera, including con siderable revision of two of the subfamilies an most of the genera. Two genera and 24 specie are proposed as new to science. The present write wishes to take this opportunity to make a correction in the nomenclature suggested by him for the specie which was identified by Kishinouye (1900) and Alcock (1906) as *Penaeus semisulcatus*. For this he offered a new name, *Penaeus bubulus* (Kubo, 1949, pp 296-301). Meanwhile Holthuis has recentl written on the identity of the species in question giving the name *Penaeus monodon* for the specie with which we are concerned, and the name *Penaeu semisulcatus* for the species identified as *Penaeu ashiaka* by Kishinouye and as *Penaeus monodon* by Alcock mostly based on the key made by D Haan (1849, p. 190). The key is as follows:- 'sulcus a basi rostri ad marginem posteriorem thoracis' for *P. semisulcatus*, and 'sulcus inte basin rostri et marginem posticum, thoracis nullus for *P. monodon*. The present writer overlooked thi key in the course of his previous study of the penaeids *Penaeus bubulus* therefore becomes a synonym *Penaeus monodon* of De Haan and Holthuis.

Finally it should be mentioned that Kubo (1954 1955a) recently proposed a new name, *Metapenaeus burkenroadi*, for the form known as *Metapenaeus affinis* since Kishinouye (1900), after a comparative study of two sets of specimens, one of seve individuals of *M. affinis* trawled from creeks nea Karachi, Pakistan, in October 1953, and the other o a number of specimens obtained from various localities of Japan. These two forms are easily separable from each other on the basis of differences found on their petasma and thelycum.

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11

ERVATIONS UPON THE BIOLOGY, ECOLOGY AND LIFE HISTORY)F THE COMMON SHRIMP, *PENAEUS SETIFERUS* (LINNAEUS), ALONG THE SOUTH ATLANTIC AND GULF COASTS OF THE UNITED STATES

by

W. W. Anderson[*]

United States, shrimp is by far the most fishery resource of the States bordering on th Atlantic and Gulf of Mexico, being in volume only by the menhaden which, , it exceeds several times in value. This s in fact one of the top-ranking fisheries of ted States and Alaska both in value and

gh numerous species of shrimp are found e South Atlantic and Gulf Coasts, only four n in quantities of commercial importance. nmon shrimp, *P. setiferus*, is the most important commercial species, followed by the grooved *P. aztecus* and *P. duorarum*, and the sea- *iphopeneus kroyeri*, which is of least im- . All of these species belong to the family e. The common shrimp is of major im- both on the South Atlantic and Gulf the major fisheries for the grooved shrimp he Gulf of Mexico (although to a lesser n the South Atlantic also); and the sea- tilized only in the Louisiana fishery, and drying purposes.

description of the development of the methods of fishing, facilities, geographical ions, main fishing areas, and seasons, ntering the catch and catch statistics, refer rson, Lindner and King, 1949.

eport to follow will touch upon the biology, and life history of the common shrimp, *setiferus*, along the South Atlantic and Gulf of the U.S. The material presented was largely from Lindner and Anderson To a lesser extent material was obtained blished papers listed under 'References.'

empt will be made to justify the statements this has been done in the original papers.

ommon shrimp is most abundant in areas characterized by having an inland, brackish connected by passes with an adjacent shallow, off-shore area of relatively high salinity and mud or clay bottoms. The off-shore characteristics seem to be required by adults and perhaps also by the larvae, while the inland marshes appear to be required by the post-larval pre-adults. The adults are rarely found in abundance in the Gulf of Mexico in depths greater than 30 fathoms, and along the South Atlantic Coast the distribution appears limited to a narrow coastal belt not more than 8 to 10 miles off the coast and in less than 10 fathoms of water. The pre-adults inhabit brackish water and at times are found in water that is almost fresh.

Spawning

The females do not carry the eggs after fertilization takes place but deposit them directly into the water. The male attaches a spermatophore to the female some time prior to the emission of the eggs. Eggs are fertilized upon emission by the sperm contained in the spermatophore. A female will produce from 500,000 to 1,000,000 eggs in a single spawning, and it is probable that there is more than one spawning a season—at least for some females.

Most, if not all, spawning takes place at sea and not in the estuarine inland waters. It appears likely from available evidence that there is little difference between the spawning seasons in any of the localities studied along the South Atlantic and Gulf Coasts between South Carolina and Texas. There probably is not more than about 2 weeks' difference in the beginning of spawning between any of the localities. Spawning may start later and end earlier in some sections than it does in others, but in all of the localities it probably begins either during the latter part of March or early in April and may possibly continue into November, although it is practically completed by the end of September. There is evidence of two peaks of spawning success—one in April and May and the other toward the end of the spawning period. These appear associated with and probably caused by the habits of the shrimp and temperature.

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ief, South Atlantic Fishery Investigations, U.S. Fish & Wildlife Service.

Larval development

The larval development of the common shrimp apparently covers at least ten distinct stages excluding the demersal spherical egg. These consist of five naupliar, three protozoeal and two mysis stages.

In brief, the larval development of *P. setiferus* requires from two to three weeks. Some twenty to twenty-four hours after the egg is spawned, the nauplius breaks the chorionic membrane and emerges. This minute organism (about 0.3 mm. in length) is to a great extent at the mercy of the prevailing currents, but is capable of some movement. During the next twenty-four to thirty-six hours the nauplius undergoes five successive molts to become a protozoea of approximately 1.0 mm. in length. It now has seven pairs of appendages, a pair of sessile compound eyes and a complete alimentary tract consisting of mouth, esophagus, stomach, intestine, and anus. Prior to this stage the food of the nauplius has been the yolk material carried over from the egg. This food supply is now exhausted, and henceforth the protozoea must capture its own food in order to survive. This transitional period is a critical one.

The third protozoea stage is followed by the first mysis which is about 3.5 mm. in length and possesses fourteen pairs of functional appendages and on the abdomen five pairs of buds which will soon become the pleopods. In the second mysis the pleopods are well developed, and rudimentary gills have made their appearance on the thoracic somites. With the succeeding molt the organism ends its larval phase and assumes the general proportions of a miniature adult. At the end of two post-larval stages and fifteen to twenty days after hatching, the young shrimp is only 5 to 6 mm. in length and is still planktonic. During this period of early development, the young shrimp have moved from the saline offshore spawning area to the brackish inside marshes, bays, and estuaries. Upon reaching these 'nursery grounds' they adopt for the first time, it is believed, a benthic existence.

The factors responsible for this inshore movement of larval shrimp have not been determined, but it is believed that for the young to reach the nursery grounds they must encounter favourable incoming currents. While capable of some movement, and perhaps responsive to a salinity gradient, they would certainly be quite helpless against outgoing currents. If spawning occurred at sea close to an inlet, the eggs could be swept through the passes on incoming currents, and the larvae reach the nursery grounds within a few hours.

Young shrimp

Young shrimp approximately 7 mm. in length are found during the spring and summer months in the brackish areas which serve as their nursery groun for the next four to eight weeks of their existenc This habitat is a rich feeding ground with shallo water, muddy bottoms, rather widely fluctuatin seasonal temperatures, and moderate to low salinity

As the young grow, they move from the shall waters of the marsh, bayou and lagoon into th deeper creeks, rivers and bays, making their firs appearance on the inside fishing grounds when abou 50 mm. long. The young first appear in th estuarine fishing grounds in June or July, dependin upon the area, and by July or August they hav begun to make their appearance in outside waters Generally in the estuarine waters there is a gradien in size of the shrimp, smaller shrimp occurring those waters farther inland and larger shrimp those waters nearest the open ocean. This grad in size appears more closely associated with loca than with salinity.

Growth

Growth data were obtained from shrimp marke in various areas of the fishery along the Sout Atlantic and Gulf Coasts of the U.S. The effectiv range of these data is from 100 mm. to 180 m From other sources the growth of shrimp smalle than 100 mm. has been estimated.

Growth is rapid during spring, summer and earl fall, and negligible during winter. This suggest that the periods of rapid and slow growth are associated with temperature, and if this is so, we coul expect them to vary somewhat from year to year an with locality. Our understanding of the growth i further complicated by the fact that shrimp different sizes grow at different rates. The rapi growing season is from about March until the end o October.

We believe that shrimp reach about 80 mm. i length (from tip of rostrum to the end of telson approximately two months after hatching. On thi basis and applying the established growth rates a example of growth is: Spawning on May 1; youn shrimp reached a length of approximately 80 m by July 1, 110 mm. by August 1, 130 mm. by September 1, 145 mm. by October 1, and 158 mm. b November 1. Growth from November 1 to Marc 1 would be negligible but if we assume that 2 mm growth occurred during this period our shrimp woul be about 160 mm. in length on March 1—th beginning of the spring rapid growing season. Th shrimp would then reach a length of approximatel 168 mm. by April 1 and about 173 mm. by May It would be approximately 1 year old, mature an spawning during this spring season. Since th spawning season covers a period of 6 months o longer any number of combinations of growth ar possible depending on the month spawned.

ons

ions were determined by tagging. The
shrimp has very definite patterns of move-
it these vary in different areas.

und that in one respect the movements of
shrimp were similar in all localities studied
outh Atlantic and Gulf Coasts of the U.S.
young shrimp first appeared on the inland
rounds they gradually worked their way
he sea. This movement from inside waters
e waters speeds up during two periods of
—at the onset of winter and in the spring.
o periods seem to be associated with two
f shrimp, the early-spawned group, and the
wned group.

he shrimp reach the outside waters their
ts vary with size of shrimp, locality, and
y also the time of the year. Small shrimp,
less in total length, did not undertake any
movements. Upon reaching the outside
ney remained there, almost immediately
to their inland nursery grounds. The
imp, more than 13 cm. in total length,
quite distinct behaviour patterns which
th locality. These will be summarized on
hical basis.

c Coast : Briefly our results indicate that
he common shrimp of the Atlantic Coast,
rating from inshore to offshore waters, do
into very deep water far from the coast.
they make seasonal migrations parallel to
line, moving southward during the fall and
ter and northward in late winter and early
During late spring and summer, their
ts are limited and random, so that they
the same general area. The larger speci-
much more prone to move considerable
than are the smaller individuals. The
nown southward migration was performed
mp released in North Carolina in October
tured 95 days later off the east coast of
about 360 miles south of where it was
The greatest northward migration was
for a specimen released in central Florida
y and recaptured 168 days later off the
South Carolina after it had gone about 260

n Gulf East of the Mississippi River : Tag-
limited to fall and winter months in the
een Mobile Bay, Alabama and the mouth of
ssippi River. All that can be indicated at
bout the movement of the shrimp in this
hat during the fall and winter they tend to
deeper water and toward the mouth of the
i River.

Northern Gulf West of the Mississippi River : In brief, along the Louisiana coast west of the Mississippi River the large shrimp moved offshore and scattered out during fall and winter. At all times they appear to be drifting about, like cattle on open range land. The only definite patterns were offshore and onshore movements, which evidently were associated with temperature changes and spawning, and a tendency to concentrate in certain areas, probably because of better feeding conditions. We believe the more or less aimless wanderings of the shrimp (but not the offshore and onshore movements) represent a search for food.

There appeared to be a natural barrier at the Mississippi River for we found neither east-west nor west-east crossings.

Central Texas : Results of tagging in this area are inconclusive due to distribution of the fishery when the marking was done. Indications are that shrimp from the central and southern part of Texas move south to the coast of Mexico during the fall and early winter, probably comparable to the movement along the South Atlantic Coast of the U.S. Likewise there is evidence of a springtime south-to-north migration from northern Mexican waters to Texas waters.

Longevity

Mortality of shrimp is apparently high and the number that live more than one year is small with respect to the total population and is probably not of great practical importance. Some shrimp live at least 16 months and possibly longer.

Temperature and salinity relations

While our temperature and salinity data are considered inadequate and are not as extensive as the biological observations, certain correlations are indicated in sections of the fishery where our most complete records are available. These observations may eventually be shown to apply to the entire fishery.

It appears that growth slows to practically nothing near the end of October when the water temperature drops to about 20°C and is resumed in the spring when the temperature again reaches approximately that value.

Spawning appears to be more closely associated with rising and falling temperatures than with absolute temperature. The comparatively abrupt rise in the spring temperatures coincides rather closely with the beginning of the spawning season and may, indeed, initiate it, while the season seems to terminate as soon as the temperatures begin to decline rapidly in the fall, even though they are at that time appreciably higher than those which evidently induced spawning in the spring.

At first appraisal it would appear that there is little relationship between temperature and migrations. For example, in Louisiana, spring-spawned shrimp appear first in the trawl catches in inside waters in June, in outside waters adjacent to the coast in July, and offshore in August. This well-defined outward movement cannot be temperature-induced, since it occurs well before there is an appreciable drop in temperature. Judging from the behaviour of the shrimp during this period, we believe the offshore movement is primarily associated with the approach of adulthood and spawning. However, this offshore movement is later accelerated by falling temperatures. The phenomenon, evidently initiated by physiological changes in the organism itself, seems to be hastened and intensified during fall and winter by the external factor of declining temperatures.

Concomitant with the accelerated fall and winter offshore movement of the adults and sub-adults, the smaller, more immature shrimp move from the very shallow inland waters toward the Gulf of Mexico. These very small shrimp, which during summer are most abundant towards the heads of the bays are, during mid-winter, more abundant near the mouths of the bays and in the Gulf adjacent to the shore, where the temperatures are not so readily depressed.

A similar situation exists along the South Atlantic Coast. However, when the temperature begins to decline rapidly in the fall, the larger shrimp move southward along the coast rather than offshore as they do in Louisiana.

This change in habitat caused by winter temperatures can probably best be described as a general shift towards warmer waters, but with all sizes of shrimp still maintaining their size-locality separations.

Sudden, severe drops in temperatures in some localities will kill shrimp and in other localities will cause them to move offshore considerably beyond their normal range. It appears from the winter distributions of shrimp that the smaller shrimp are probably less susceptible to cold than are the larger ones.

The reaction of the shrimp to salinity is not clear-cut. The young go to the inland areas of low salinity, and on approaching adulthood they move towards the more saline waters of the sea. It seems to us that the shrimp (at least the sub-adults) are rather insensitive to large fluctuations in salinity, but that they are quite sensitive to small changes in temperature.

In every locality, our trawl samples would almost always yield the smallest shrimp in the inside waters farthest from the sea, and the largest in the outsi waters. In general there was a progression in t size of trawl-caught shrimp, with the smallest or in the waters of lowest salinity and the largest the highest salinity. However, due to other co plicating factors this apparent relation between s of shrimp and absolute salinity within relativ large ranges of salinity probably does not exist. T relation normally is between size and locality. Th is, certain sizes of shrimp will be found in certa localities at certain seasons regardless of what t salinity may be (within relatively wide limits) at th particular locality and time. This does not mea however, that there is no relation between size a salinity. Why is it that as the shrimp increas size they head for the sea ? We suspect this to reaction to salinity, related to spawning or matur We have observed that if the salinity becomes low in an area, the shrimp will leave.

In winter there is a definite relation between s and temperature, with the largest shrimp seeking t warmest temperatures. This correlation does n exist during summer. In fact summer size-tem perature relation is negative, but we can see no caus and-effective connection.

General

Perhaps the shrimp is its own worst ene Data from Louisiana (the area of greatest abu dance) are suggestive of this. In spite of appare continuous spawning throughout the entire seaso evidently only the earliest and latest spawnings a really successful, and the latest spawning is conco tant with the earliest-spawned shrimp moving o shore from the inland nursery grounds. The seco successful spawning in Louisiana (and the last in other localities) does not seem to occur until v numbers of shrimp have departed from the nurse grounds. Also in Louisiana, waves of oncomi young appear to be spaced about 2 months apa which suggests spawning successes coinciding w mass departures of the preceding wave from t inner to the outer nursery areas.

Preliminary analysis of some of our data includi that derived from tagging, suggests that the ra between loss from natural mortality and gain weight through the rapid growth of the individ animals is such that the total poundage of shri available to the fisherman would be increased if shrimp were protected from the time they appe the inside fishing grounds in summer until they m to outside waters in fall. Likewise, on this sa basis, it might be advantageous to afford protecti to the small shrimp while they are growing rapi during early spring, or possibly to this same gr during winter.

rather widely accepted that in certain areas
range (notably Louisiana) the shrimp is
y the most important animal both with res-
species-mass and food conservation. When
ider this point it is unfortunate that we do
w enough about shrimp to be able to predict
y assurance what will happen to the popu-
hen man does this or that. For example
e have suggested that it may be advisable to
hing of small shrimp, on the other hand,
xploitation of inside waters may result in a
tended spawning success owing to a reduced
istic predation, with the obvious conse-
of greater production.

herefore arrive at the conclusion that well-
ed fishing experiments, together with addi-
search, are required before we can determine
y degree of accuracy how the shrimp popu-
ill respond to changes in fishing effort or in
seasons. Because the growth of the shrimp
pid, the experiments, if followed by com-
bservers and with adequate catch figures,
t be drastic in their approach. On the basis
present information, experimental fishing of
hrimp during the periods when they are
rapidly seems most promising.

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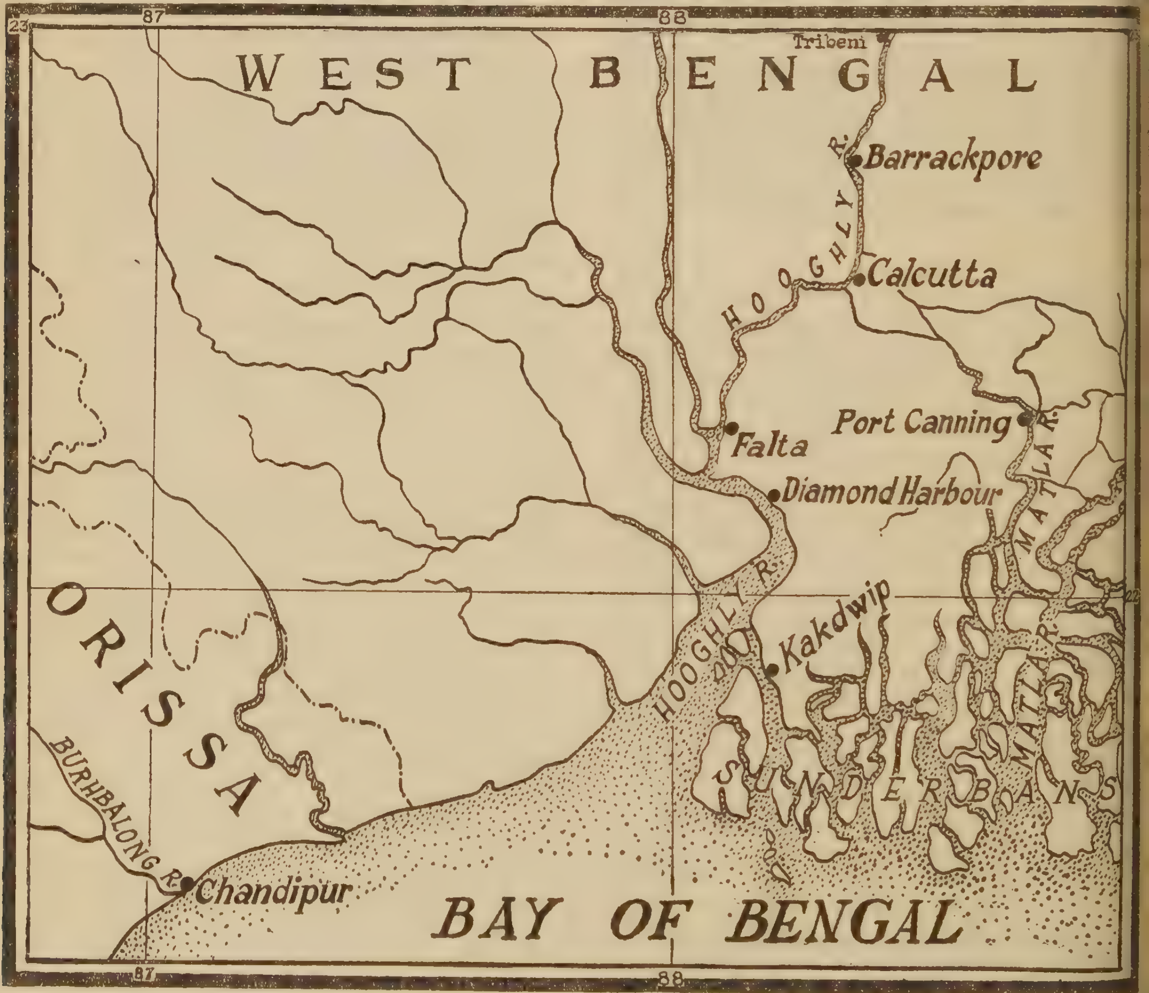
12

PRELIMINARY STUDIES ON THE BIOLOGY OF THE PALAEMONID PRAWN, *LEANDER STYLIFERUS* MILNE-EDWARDS IN WEST BENGAL, INDIA

by

M. M. Kunju*

Leander styliferus Milne-Edwards is one of the few economically important palaemonid prawns of the deltaic regions of West Bengal, the fisheries of which are of considerable commercial value. The species is smaller than the more common prawns, growing to a size of only about 110 mm. Its small size is, however, compensated by the vast numbers in which it is caught throughout the year. This prawn, along with an allied species, *L. ten* Henderson is very common in the Gangetic Very little work has been done on the biology of palaemonid prawns of India and practically not has been done on the Indian species of *Lea* except for the short account given by Pillay (on the food of *L. styliferus* in a brackishwater in Gutiari Sharif.


87
88
23
22
WEST BENGAL
Tribeni
Barrackpore
HOOGHLY R.
Calcutta
Port Canning
Falta
Diamond Harbour
MATLA R.
Kakdwip
HOOGHLY R.
ORISSA
BURHBALONG R.
Chandipur
SUNDERBANS
BAY OF BENGAL

Map of West Bengal and Orissa showing the collection centres

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* Central Inland Fisheries Research Station, Calcutta, India.

al and Methods :

rial for this study was collected from the rcial catches at Port Canning on the river , and Kakdwip, Diamond Harbour, Falta and a along the River Hooghly in West Bengal. s collected from Chandipur in the Burh- estuary were also examined. The size cy studies were based on random samples d regularly during the period from June 1953 ember 1954 from Port Canning, where the is found in more abundance than at other of observation. The gear used (described sequent section) in catching these prawns is identical in all the above places, and other are seldom employed. All the specimens in mple were measured from the tip of the to the end of the telson by means of a ed measuring board.

length-weight relationship was determined n the data for 1188 specimens collected at nning from June 1953 to May 1954. For ly of the food and feeding habits, 352 prawns pled from the collections from Port Canning, d Harbour and Falta were examined. of techniques employed in the study are d in the appropriate sections.

ution and Habitat :

liferus has a fairly wide distribution all along sts of India, Pakistan and Burma where a -water environment is available for the com- f its life cycle. According to de Man (1908) cies ' inhabits an estuary of the Ganges, the ans, Mergui, the Gulf of Martaban and ' Kemp (1917) when discussing the dis- n of the species, added Chilka Lake, Chitta- nouths of the Ye and Rangoon rivers and erim to the range of distribution, and also ed the record of a single individual from The species occurs on the Bombay coast constitutes an important fishery (Rai, 1933) he backwaters of Travancore-Cochin where of some economic value (Menon, 1954).

s predominantly a marine species capable of g very low salinity but very rarely fresh- onditions. Though in the Hooghly this ccurs normally only up to Calcutta, a single al has been collected in May, 1954 from as the estuary as Tribeni which is situated ndred and forty miles from the sea shore, e water is practically fresh throughout the emp (1917) has cited the occurrence of the n a freshwater creek in Diamond Harbour. s to rear the animals in freshwater in the y were unsuccessful as they did not survive than about three hours. The prawn occurs numbers in the Matlah up to Port Canning, in the Hooghly up to Diamond Harbour and Falta, and at Chandipur in Orissa where the hydrological conditions are typically estuarine. At Port Canning and Chandipur these prawns are of considerable economic importance and are fished in large quantities almost throughout the year.

Food and Feeding Habits :

An account of the food of *L. styliferus* in a brackish-water *bheri* is given by Pillay (1954). Further study of this aspect was considered useful to ascertain how the food varies at different times and at different places. Hence 352 selected representative specimens were examined from the random samples collected from Port Canning, Diamond Harbour and Falta in different months.

In some months the prawns were seen with the oral region stained black. Examination of this stain revealed it to be semidigested food items with debris. This may perhaps be due to the prawn vomiting the stomach contents while struggling for life in the net. Only rarely however has it been found that the entire stomach content is lost in such prawns. Forster (1951*a*) has observed that most of the stomach contents were lost in the case of *L. serratus* when these prawns were placed in formalin while still alive.

The stomach of the prawn was dissected out as soon as practicable, after having noted its length and distension of the stomach. The larger items in the stomach contents were identified as far as possible under a magnifying lens and the remainder was examined under a high power microscope.

The quantitative analysis of the food of the prawn has been done by estimation of percentage by volume as followed by Pearse (1915) in the study of the food of fishes. According to this method, ' the contents of each sample are considered to be unity, the various items being expressed in terms of percentage by volume as estimated by inspection '. In the final analysis the percentage of stomachs containing the different food items was also worked out. Detailed qualitative determination of the different items of food was rendered extremely difficult due to the fact that prawns ingest the food only after chewing the same by means of their powerful mandibles and also because the ingested food is immediately afterwards subjected to a good deal of churning and grinding by the masticatory stomach. Therefore, identification of these items was possible only up to the broad groups ; nevertheless, the items were, wherever possible, identified to genera and species.

The food consumed by *L. styliferus* in the three different areas is found to be almost identical and no appreciable difference was noticed in the stomach contents of the different size classes. There was no significant variation in the food consumed in different months except for the quantitative fluctuations consequent on the availability of the various items of food. The average percentage composition of the various constituents of the stomach contents are presented in Table I.

About 25% of the prawns examined were found to be with empty stomach. *L. styliferus* is a delicate animal and dies even before the net is emptied of the catch, unlike some other prawns which can live for some time on land. The presence of empty stomachs cannot, therefore, be the result of digestion during the time interval between capture and death. The vomiting previously referred to was confined to a few prawns in certain months. The biological significance of the occurrence of so many prawns with empty stomachs is, therefore, not quite clear.

TABLE I

The average percentage composition by volume and occurrence of the constituents of the stomach contents of 352 speimens of *L. styliferus*

Stomach contents	Percentage composition by volume	Percentage of occurrence
Sand grains	22.7	53.4
Debris	38.6	70.3
Crustacea		
Decapods (*Acetes* spp., peneid and palaemonid post-larvae, *Megalopa*, etc.) . .	9.2	10.5
Copepods (*Acartiella* spp., *Diaptomus* spp.)	6.1	9.7
Mysids (*Macropsis orientalis*, *Potamomysis assimilis*)	2.0	4.4
Other crustaceans (fragments of crustacean cuticle)	8.1	28.9
Fish-larvae	6.7	15.7
Insects	2.9	6.3
Algae (filamentous green algae, *Coscinodiscus*)	1.0	2.4
Macro-vegetation (pieces of dried grass and leaves)	2.0	6.9
Miscellaneous (Gastropod shells, gastropod larvae, foraminiferan shells, sponge spicules).	0.7	3.3

Observations on Stomach Contents :

Sand grains. Prawns are, as a rule, bottom feeders preferring mud flats and therefore a good amount of sand grains naturally is consumed along with the food items. It is improbable that these sand grains have any nutritional value for the animal. About 22% of the stomach contents by volume is constituted by this item and it occurs in about 53% of the prawns examined.

Debris. This category includes all unidentifiable finely divided matter. It was not always possible to decide whether the debris had been ingested as such or was formed in the stomach when the different food items were ground up. This item was found in considerable quantities in almost all the specimens from the three centres.

Crustaceans. Small crustaceans nearly always formed a significant proportion of the diet, constituting about 25% by volume. Fragments of cuticle were very often found in the stomach contents and it was extremely difficult to distinguish whether they represented parts of a 'moult' or the remains of a whole animal.

Small decapods, copepods and mysids were the identifiable crustaceans. The decapod item often included species of *Acetes* which are quite common in vast shoals in the Gangetic estuaries, particularly in the Matlah. *Acetes* formed an appreciable portion of the stomach contents of the Matlah specimens during the months from January to May when it is very abundant in the river. Other decapods recognisable were post-larval palaemonids and peneids and megalopa larvae of crabs. In a few instances cuticle fragments of *L. styliferus* were found in the stomach contents. Probably this is due to the prawn eating up its own cast exosketelton immediately after moulting, rather than to cannibalistic tendencies. The habit of consuming its own 'moult' has been observed in certain decapod crustaceans, as for instance in *L. longirostris* by Gurney (1923) and in *Crangon vulgaris* by Lloyd and Young (1947). The present writer has observed this habit in *L. fluminicola*, a closely allied species, while rearing the animal in the laboratory. Copepods (*Acartiella* spp., *Diaptomus* spp.) were found in larger proportions in the Diamond Harbour and Falta specimens. Mysids (*Macropsis orientalis* and *Potamomysis assimilis*) were absent from the prawns collected from Falta where it has been observed that only rarely do these mysids occur in large numbers. At the other two centres mysids formed a minor item of food. Portions of crustacean cuticle which were very often found in the stomach contents could not be identified with any amount of certainty and so they are classified as other crustaceans.

. Skeletal parts and scales and sometimes ns of fish larvae were frequently found, parti- in the stomachs of the prawns from Falta and nd Harbour, where during the post-monsoon s fish larvae are found in very large numbers. wing to the advanced stages of digestion of arvae, it was not possible to identify them.

cts. The stomachs of a few prawns from and Diamond Harbour contained portions of cuticle, such as wings, elytra and other appen- This item was particularly abundant in 954 in the prawns from Diamond Harbour, August and September 1954 in the specimens alta.

t matter. In a very small number of stomachs nts of green algae were found and because the plast was mutilated on account of digestion ould not be identified. Sometimes pieces of grass and leaves, and rarely diatoms (*Coscino-* were seen. This item might have been con- along with the bottom debris.

ellaneous. This category includes portions ropod shells, gastropod larvae, foraminiferan monaxon spicules of sponge etc., which d in rare cases.

s seen from the above analysis, *L. styliferus* erally omnivorous like most Decapoda, and t the bottom. The virtual absence of algae em of food is noteworthy in view of the find- other workers who observed that algae con- an important item of the diet of *Leander* spp. (1954) observed that the diet of *L. styliferus* ackishwater *bheri* near Port Canning consisted of microbenthic vegetation and organic det- und on the bottom of the pond. According t (1944) the food of *L. debilis* and *L. pacificus* aiian fish ponds consisted primarily of microbenthos and detritus. In the English Channel and the connected estuarine regions, *L. serratus* and *L. squilla* were found to feed mainly on filamentous algae (Forster 1951 *a* and 1951 *b*). In view of the occurrence of algal elements in the aquatic vegetation of Port Canning, Falta and Diamond Harbour, the virtual absence of these in the stomach of *L. styliferus* in this environment is very striking.

The fragments of larval crustaceans found in the stomachs of *L. debilis* and *L. pacificus* are considered by Hiatt (1944) to be part of the detritus or present as a result of scavenging activity. But, in the present study, as well as in *L. serratus* (Forster, *loc. cit.*) small crustaceans have been found to be a principal item of food. It was impossible to ascertain whether these crustaceans and other small animals found in the stomach have been captured dead or alive. But, since observations by other authors have shown that *Leander* can catch small amphipods and other crustaceans (Forster, *loc. cit.*) and even catch and devour active specimens of other small decapods (Hunt, 1925), it appears that it might not be so much of a scavenger as is commonly supposed. Nevertheless, a great deal more must be known of the food organisms and the digestive powers of prawns before definite conclusions can be drawn on this aspect.

Length-Weight Relationship :

The length-weight relationship was established from measurements of 1188 prawns from 26 to 90 mm. in total length collected from Port Canning during the period from June 1953 to May 1954. The larger prawns were weighed in a platform balance of an accuracy of one-tenth of a gramme, and the smaller ones in a more accurate physical balance, after blotting out the excess of moisture on the animals.

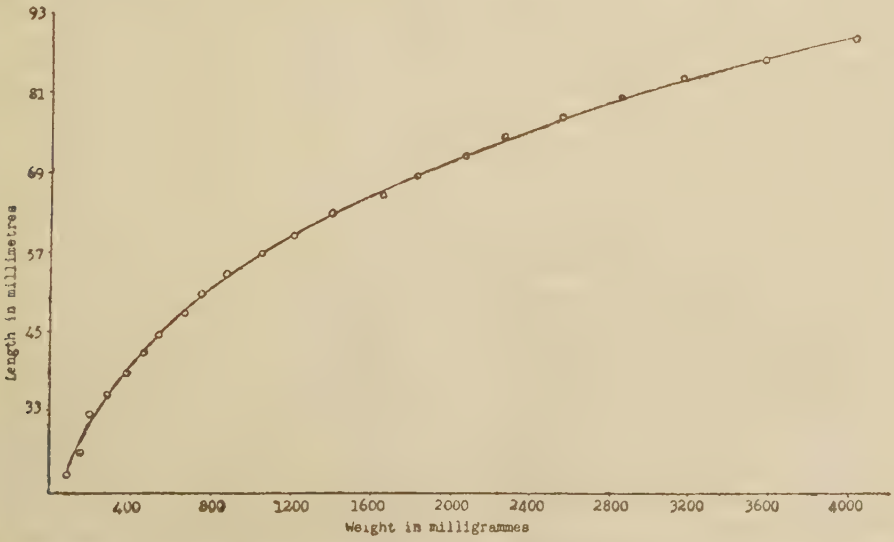

Fig. 1. Calculated length-weight curve (solide line) fitted to the average length-weight values (circles) of *Leander styliferus* Milne-Edwards.

As the regression of log W against log L was found to be a straight line, the relationship was determined by means of the general formula

$$W = c L^n$$

where W = weight in grams, L = length in millimetres and c and n are constants.

The length-weight data were arranged according to length groups of 3 mm. and the logarithms of the mid-points of the various groups were plotted. The resulting curve was definitely a straight line. The value of n was calculated by employing the formula

$$n = \frac{\frac{\Sigma X}{N} - XY}{\frac{\Sigma X^2}{N} - (X)^2}$$

where $X = \log L$ and $Y = \log W$. The value of log c was calculated by using the formula,

$$\log c = \text{Mean of } \log W - n\,(\text{Mean of } \log L).$$

The equation relating log W to log L was therefore obtained as follows:

$$\log W = -5.02108 + 2.8754\,(\log L)$$

or expressed in the anti-log form:

$$W = .0000095\, L^{2.8754}$$

The calculated weights for *L. styliferus* are shown in Table II and these give, as shown in Figure I, a good fit to the class means of the observed weights. It is seen that the weight of *L. styliferus* increases at a rate slightly less than the cube of its length.

Egg-carriage and Ovigerous Setae:

The number of eggs carried by a berried female varies from 1,600 to 3,800 depending on the size of the animal. The smallest egg-bearing female noticed during the period of investigation so far, is 68 mm. and the largest 86 mm.

TABLE II

Average observed and calculated weights of *L. styliferus*.

Size group (mm.)	Mid-point (mm.)	Number of individuals	Average observed weight (mgm.)	Calculated weight (mgm.)
26-28	27	3	150	124
29-31	30	0	. .	168
32-34	33	3	200	221
35-37	36	2	275	284
38-40	39	23	376	357
41-43	42	50	488	443
44-46	45	81	536	540
47-49	48	95	670	650
50-52	51	129	755	774
53-55	54	109	884	913
56-58	57	155	1,062	1,066
59-61	60	135	1,223	1,236
62-64	63	138	1,420	1,422
65-67	66	111	1,669	1,625
68-70	69	69	1,846	1.847
71-73	72	47	2,088	2,087
74-76	75	21	2,274	2,347
77-79	78	8	2,550	2,623
80-82	81	3	2,833	2,928
83-85	84	3	3,167	3,251
86-88	87	1	3,600	3,596
89-91	90	2	4,050	3,964
Total number of individuals		1,188		

The pleopods of the female undergo considerable change during the breeding period. Along the inner edge of the basipodite of the first four pleopods of the adult female are seen a row of tubercle-like structures in varying numbers in the different pleopods, which are the precursors of the ovigerous setae. Sollaud (1922) termed these structures 'late secondary sexual characters'.

During the moult immediately preceding the extrusion of eggs these structures emerge as non-plumose setae on which the eggs are eventually carried. These setae are not the same in number in each pair of legs, but have a remarkably regular arrangement. In all the first four pleopods are seen a crest at the inner proximal end of the basipodite. Over this crest on the first three pleopods there are ng and two short setae, and in the fourth l two long and two short ones. In all these eopods a long seta is found in the level of the on the flat inner surface of the basipodite. jor portion of the eggs is carried by the female e long setae and the short ones do not appear any ovigerous function. In a berried female 600 eggs, about 1,200 were seen attached to the tae. The rest of the eggs is carried by the us setae distributed along the inner edge of ipodites of the first three pleopods, down the n each of which there are four long and a number of short setae. The fifth pair of ls is completely devoid of any ovigerous setae.

presence of these non-plumose ovigerous ay be taken as a certain indication that eggs ut to be laid, or that young have been hat- while their loss marks the end of the breeding

ng :

ton and townet collections made from areas salinity where berried females are found in months of the year (Table III), for example, nning, Calcutta, Falta, and Diamond Har- ave failed to show any larvae or post-larval f *L. styliferus.* The eggs carried by the berried females in these areas were never found to be in an advanced stage of development and ready for hatching, nor was any prawn found to be 'cemented' after having released the young ones. Moreover, the percentage of berried females found in these areas is negligibly small, whereas during the same months they were collected in larger numbers from the mouth of the Burhbalong estuary at Chandipur in Orissa. These facts suggest that these prawns probably migrate seaward at the end of the period of egg-carriage for liberation of the young ones. Comparable observations on other species of *Leander* inhabiting the estuaries and rivers of Europe have been made by previous workers. Gurney (1923) has stated that *L. longirostris* found in the rivers of Norfolk in England migrates into salt water as the time of hatching approaches. Similar breeding migrations have been observed by Mortensen (1897) in *L. adspersus*, by Forster (1951*a*) in *L. serratus*, and by Gurney (1923) in *L. squilla.*

The breeding period of *L. styliferus* seems to be very extended as is evidenced by the presence of berried females from October to July. Regular observations were carried out at Port Canning where the ovigerous females are found only from March to June. Probably the peak breeding season is from April to July, since it is during these months that

TABLE III

The occurrence of berried *L. styliferus* in different periods

Month	Chandipur	Port Canning	Diamond Harbour	Falta	Calcutta	Remarks
— —	..	..	×	..	..	
— —	..	..	×	..	..	
— —	..	×	..	..	..	
— —	..	×	..	..	..	Found in larger numbers.
— —	×	×	×	×	..	,,
— —	×	×	×	×	×	,,
— —	×	..	..	×	..	,,
— —	..	..	..	..	..	
— —	..	..	..	..	..	
— —	×	..	..	..	..	
— —	..	..	×	×	..	
— —	..	..	×	×	..	

(× indicates the presence of berried prawns) larger numbers of egg-bearing females are found in the various estuarine centres.

The above conclusions do not support the view of Kemp (1917), that *L. styliferus* is apparently a seasonal immigrant to brackishwater, ascending estuaries and tidal rivers, possibly for breeding purposes, when the monsoon floods are abating. Rai (1933) has mentioned that the species breeds during September in Bombay.

Sex Ratio :

A knowledge of the sex ratio in populations is necessary in the management of a fishery as it will be advantageous to devise means of ensuring a proportional fishing of the two sexes. Sex in *L. styliferus* was determined by examining the secondary sexual characters. As there is no marked external difference between the two sexes and no sexual dimorphism in the first pleopod, the second pleopod of each individual was examined under a magnifying lens and those in which the appendix masculina was present were taken as males and the rest females. In individuals below 26 mm. in length, sex determination was not possible, since it appears that the secondary sexual characters are developed only at this stage. This compares with the case of *L. serratus*, the common British prawn in which the appendix masculina is found to develop only in individuals 25 mm. and over (Forster, 1951 *a*).

In the random samples from Port Canning there were 44% males and 56% females, with a negligible number of indeterminates. Thus, there is a higher proportion of females in the population. The size frequency of the males and females from Port Canning in 3 mm. class ranges of total length is given in Table V. The number of females is almost always greater than the number of males in each size class (Fig. 2).

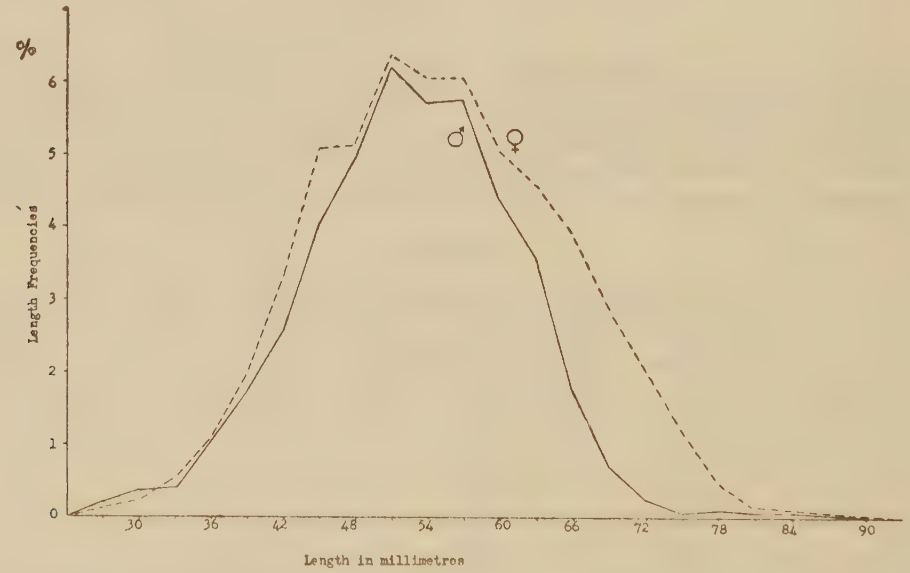

Fig. 2. Distribution of males and females of *Leander styliferus* in 3 mm. size range at Port Canning, June 1953–November 1954.

Parasitization

A bopyrid parasite, *Bopyrus squillarum* Latreille, var. *bimaculatus* Chopra has been very frequently noticed in the branchial chamber of *L. styliferus.* The prawns were found to be infested only on one side, excepting in a single instance where infestation was found on both sides simultaneously.

Out of a total of 4,425 prawns examined from Port Canning during the period of investigation, 438 (9.9%) individuals were found to be parasitized, of which 280 (6.3%) were males and 158 (3.6%) females (Table IV). This indicates that parasitism is twice as common in males than in females. A monthly breakdown of the figures also showed that the parasitized males almost always outnumbered the parasitized females. As females are found to predominate in the population, the preponderance of males among the parasitized individuals is significant. Whether some of the parasitized females of *L. styliferus* undergo sex reversal and change into males on account of the parasitism, or whether the males are more prone to infection than females, cannot definitely be inferred from the present data. However, in the infected individuals the gonads are found to be rudimentary and imperfectly developed; and the parasitized females are never seen carrying eggs even when they are of adult size. Similar

S 3/12

TABLE IV

The incidence of parasitism on *L. styliferus* collected from Port Canning

Month	Number of prawns in the sample	Individuals parasitized		Males parasitized		Females parasitized		Mean size of the prawns in the sample (mm.).	Mean size of the healthy prawns (mm.).	Mean size of the parasitized prawns (mm.).
		Number	Percentage	Number	Percentage	Number	Percentage			
June, 1953 —	122	14	11.5	5	4.1	9	7.4	58.85	58.89	58.57
July, ,, —	77	19	24.7	14	18.2	5	6.5	53.01	53.09	52.79
August, ,, —	408	57	14.0	30	7.4	27	6.6	57.09	57.66	53.52
October, ,, —	210	11	5.2	7	3.3	4	1.9	54.73	54.74	54.64
November, ,, —	238	14	5.9	10	4.2	4	1.7	58.03	57.95	59.43
January, 1954 —	490	14	2.8	7	1.4	7	1.4	53.48	53.49	53.14
February, ,, —	209	10	4.8	7	3.4	3	1.4	50.25	50.30	49.30
March, ,, —	684	53	7.8	35	5.2	18	2.6	50.68	51.19	44.89
April, ,, —	738	115	15.6	90	12.2	25	3.4	58.60	59.23	55.16
May ,, —	147	20	13.6	17	11.6	3	2.0	59.46	59.99	56.10
June ,, —	111	21	18.9	12	10.8	9	8.1	63.30	63.81	61.14
August ,, —	91	8	8.8	3	3.3	5	5.5	40.78	40.57	42.88
September ,, —	456	42	9.2	25	5.5	17	3.7	50.09	50.20	49.00
October ,, —	214	16	7.5	10	4.7	6	2.8	50.39	50.63	47.44
November ,, —	230	24	10.4	8	3.5	16	6.9	50.66	50.80	49.50
Total —	4,425	438	9.9	280	6.3	158	3.6			
						Grand mean		53.96	54.17	52.50

instances of inhibition of sexual activity in prawns in Indian waters due to bopyrid parasitism have been reported by Menon (1953) on *Parapenaeopsis stylifera*, and by Chopra (1923) on the genus *Palaemon*.

The mean size of the infested prawns has been found to be comparatively smaller than that of the normal ones. This indicates that the growth rate of *L. styliferus* is retarded to some degree by parasitism. The incidence of parasitism to such an extent as to infest about ten per cent of the total catch of prawns diminishes the commercial value of the fishery, inasmuch as the parasite does not permit the full growth of the host and interferes with the proper development of its gonads.

Length-frequency Distribution:

The length-frequency distribution of *L. stylif* collected from Port Canning during the period fr June 1953 to November 1954, is presented in Ta V. It has been suggested in a previous section th the animal does not hatch the young anywhere the estuarine regions of West Bengal. After hav undergone a period of growth in the lower stretc of the estuaries, the prawn probably migrates se ward for hatching the young. This trend in migration of the larger size groups is evident fr the length-frequency curves (Figure 3) in that individuals above 70 mm. in length are found o in very small numbers. This cannot be due to

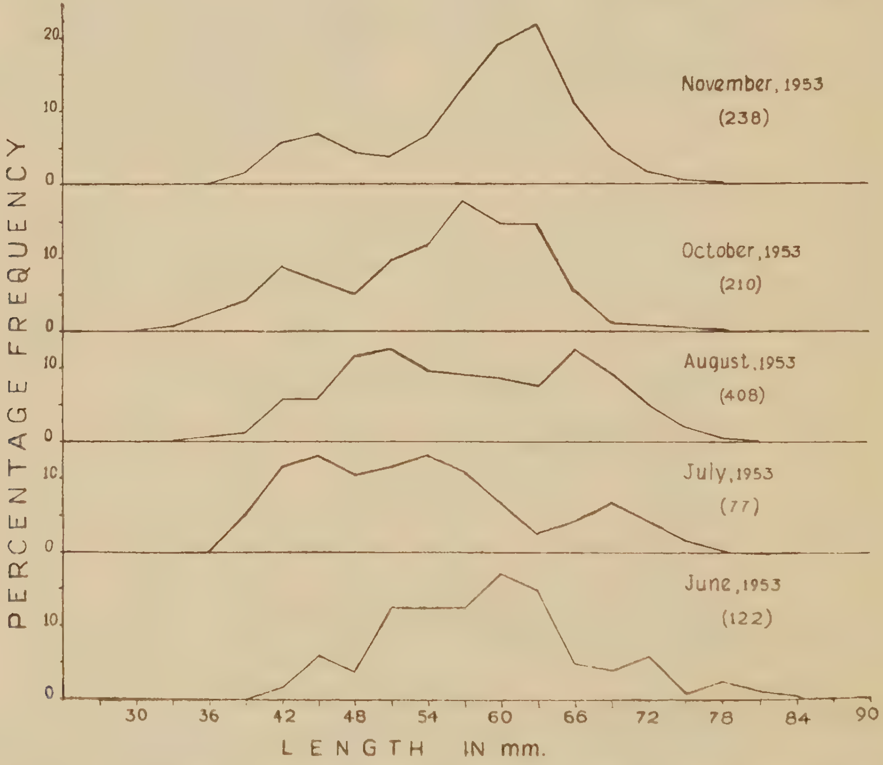

Fig. 3 (a) Length frequency curves of *Leander styliferus* Milne-Edwards at Port Canning, June-November 1953.

effect of selective fishing since the same type of gear employed at Chandipur has been found to catch prawns above 70 mm. in length in larger proportions. Whether these prawns migrating to the sea return to the estuaries after breeding, is not known.

The dominant size groups constituting the fishery of this prawn at Port Canning fall under the 45-66 mm. range, forming about 75% of the catches. The larger sized prawns are caught in greater numbers at Chandipur, thus again indicating that the species migrates to the sea for breeding purposes.

As the breeding phase is extended over a ve long period, interpretation of age and growth fr length frequency data is made extremely diffic However, certain modal groups are seen progr sively shifting to the right and ultimately disappea ing (Figure 3). The 45 mm. group in July 19 reaches the 63 mm. group by November of the sa year, so that within a period of five months animal may have grown to the extent of 18 m The modal group at 42 mm. seen in October 19 has grown to the 63 mm. size group by May 19 having grown to the extent of 21 mm. within ab ths. So also, the mode at 42 mm. in August hifted to the mode representing the 51 mm. by November 1954 and it is to be assumed rawn has grown by nine mm. within a period nths. Working out an average on the growth trends mentioned above, the growth rate of *L. styliferus* appears to be about 3 mm. a month during the period of its life in the estuaries. In the absence of other evidences this conclusion can be only very tentative.

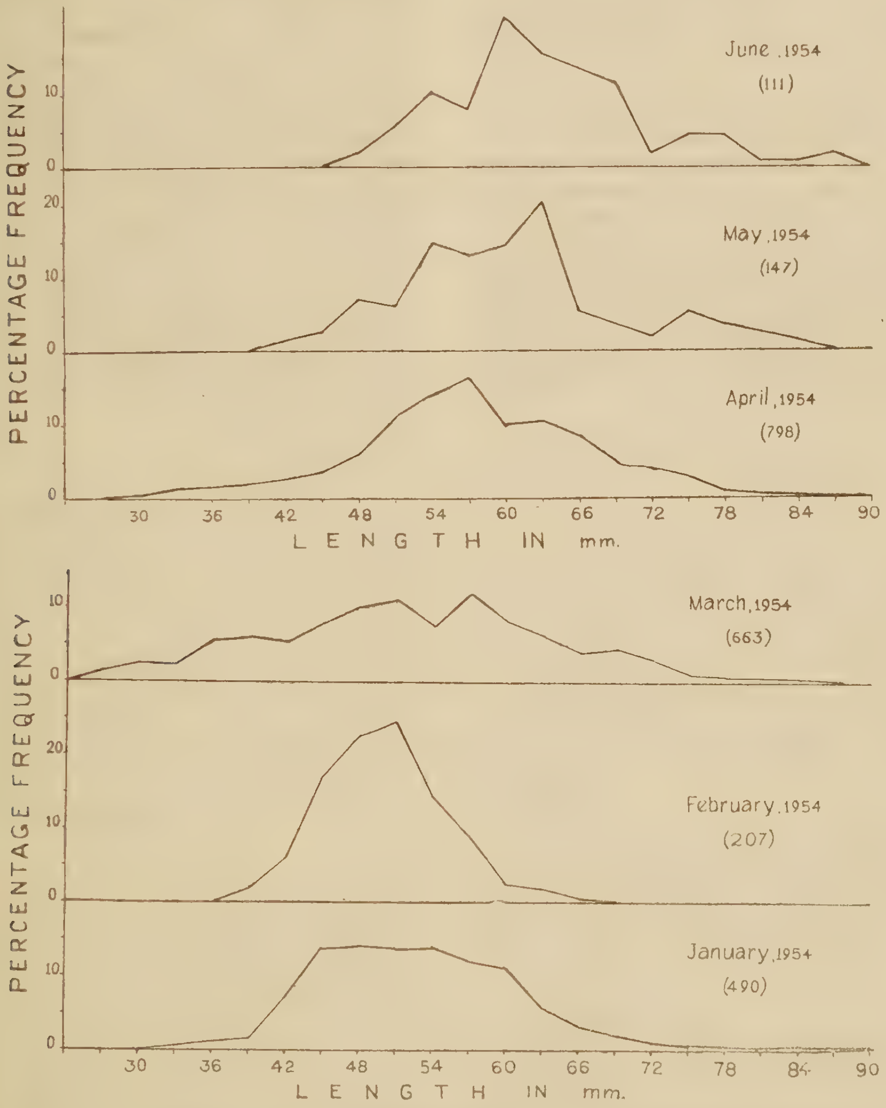

Fig. 3. (Contd.) (3b and 3b′) Length frequency curves of *Leander styliferus* Milne-Edwards at Port Canning, January-June 1954.

wn Fishery in West Bengal :

iferus is very common in the Calcutta usually frequented by the poorer section of ation. In the Matlah estuary at Port Can- prawn supports an important fishery ut the year, as has been mentioned in a pre- ction. In the Hooghly, general fishing (including the prawn fishery) are suspended during the monsoon months when the fishermen resort to the more profitable Hilsa fishing. Fishing in West Bengal is carried out primarily for the various species of fish, but prawns form a very appreciable portion of the catches, both in quantity and value. Hence, there is no exclusive fishery for *L. styliferus* anywhere in West Bengal.

Reliable statistics of catches and landings of prawns are not available. However, it has been observed during the present investigation that *L. styliferus* is of considerable economic value and about one-fifth of the quantity of prawns caught in the brackishwater regions of the Gangetic delta is composed of two species of *Leander*, viz., *L. styliferus* and *L. tenuipes*, which are very often found overlapping in their distribution.

Fishing Methods. These prawns, locally called '*Roshna*' or '*Ghora chingri*', are caught in varying quantities in most of the different kinds of nets and other capture devices used by the fishermen in the lower reaches of the estuaries of West Bengal. These include triangular dip nets (*Sitki jal*), cast nets (*Khepla jal*), drag nets (*Hata jal* and *Dhai jal*), traps (*Phanth* or *Bithi*), and the fixed bag net (*Behundi, Behuti* or *Bhin jal* and *Thor jal*), of which the last mentioned is the most important, more prawns being captured by this net than all the other types of gear mentioned above, taken together.

The *Behundi, Behuti* or *Bhin jal* has been described in some detail by Naidu (1942), Chopra (1941 and 1943) and Ahmad (1952). The *Thor jal* is very similar to the *Behundi* or *Bhin jal*, but is much smaller in size. This net is often seen operated by the sides of large *Behundi* or *Bhin jals* in the Diamond Harbour and Falta areas. The *Behundi* (or *Behuti* or *Bhin jal*) is a fixed bag net with a wide mouth, short wings and a fairly long cod end which is open terminally, but tied up with a string when the net is in operation. Near the cod end there is invariably a flap or a small inner open bag so that prawns etc. entering the [illegible] find it difficult to escape. The net is designed for operation in localities subject to strong tidal currents and the size of the net and of the mesh vary with the strength of the tides in the different estuarine regions of West Bengal. The mouth of the bag is set against the current and the water passing through it brings in large quantities of prawns and fish. When the tide turns, the nets are either removed or re-set with the mouth facing the current.

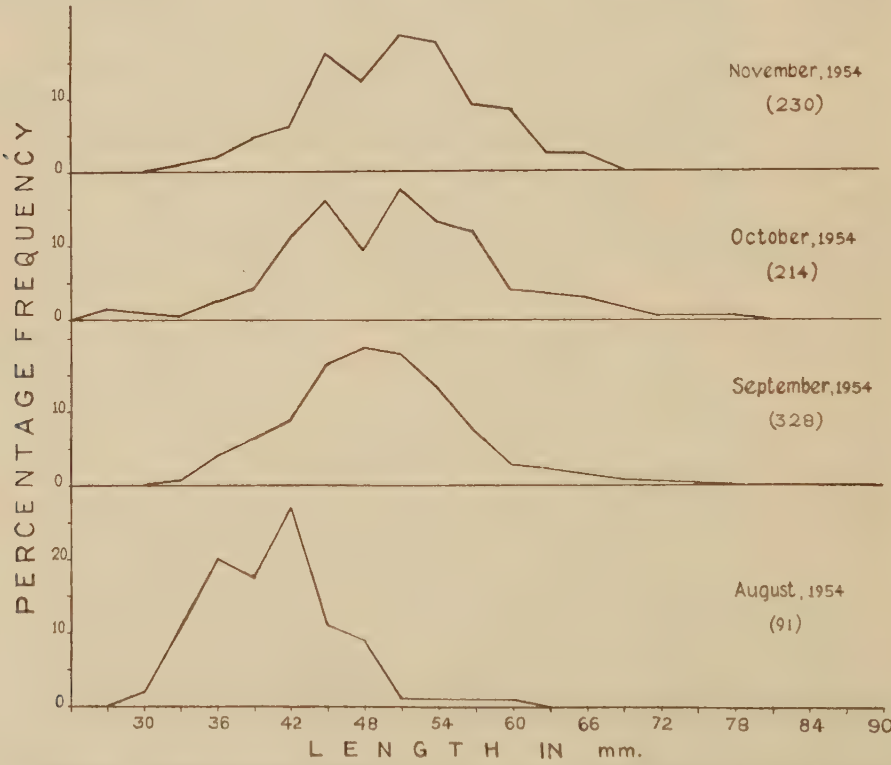

Fig. 3. (Contd.) (3c) Length frequency curves of *Leander styliferus* Milne-Edwards at Port Canning, August-November 1954.

This net, as commonly used in Port Canning, is about 70 feet long, with a mouth 30 feet wide. The mesh measurement of the bag progressively increases from 1/5 inch in the cod end to one inch near the mouth, so that very small prawns are seldom caught in this net. The length of the net varies from 20 feet to 120 feet in different parts of West Bengal. At Port Canning itself small nets of this type, 2 feet in length, locally called *Vacha jal*, are often seen being operated alongside the usual large nets.

Remarks and Conclusions :

iferus is an ' influent ' in the brackish water Bengal (Pillay, 1954). There are possi- f large scale culture of these prawns in the s *bheris* distributed over the lower regions angetic delta. At present, no *bheri* is being ly stocked with this prawn, but a well- *heri* might yield a good crop. It has been that the species feeds on microbenthic n and organic detritus in confined brackish- Pillay, 1954). Since the present study has at smaller crustaceans also form a substan- ion of its diet, the species may be suitable ing even in such *bheris* where growth of thic vegetation is poor. It may also be d here that in the experimental prawn djoining the backwaters of Travancore- L. *styliferus* is one of the species grown along er peneid prawns (Menon, 1954).

resent study has revealed that in the lower f the estuaries of West Bengal, the dominant ps fished in large quantities are constituted ture prawns. As large-sized and berried etch a higher price, it will be profitable to more extensive fishing in the river mouth ere they are found in larger proportions hroughout the year. In fact, large indi- of *L. styliferus* are caught in considerable during the winter months around Jambud- Saugor Island in the mouth of the Hooghly ighout the year at Chandipur in the mouth urhbalong in Orissa. Due to lack of faci- transporting them in fresh condition to these prawns, along with other poneid e sun-dried and transported to the dried ets in Uluberia and Howrah.

ry :

iferus, the palaemonid prawn found in very nbers in the estuaries of West Bengal has a ribution along the coasts of India, Pakistan na. Tolerance of this species to freshwater s appears to be very low.

omach content analysis of the prawn has at in the estuaries of West Bengal it feeds ottom debris and a considerable quantity of ustaceans and larval fish. No qualitative in the diet was found in the different estua- ons and in different seasons. There was a t absence of algae in the stomach contents.

eight of the prawn increases at a rate slightly the cube of its length. The formula for th-weight relationship was found to be 000095 $L^{2.8754}$ where $W =$ weight in d L = length in millimetres.

The non-plumose ovigerous setae developed by the female prawn at the onset of maturity and the mode of egg-carriage are described.

There is evidence to indicate that the species does not liberate its young in the estuaries, but probably migrates seaward at the time of hatching the eggs. The breeding period appears to be very extended, lasting over a period of ten months from October to July.

The females almost always outnumber the males in the commercial catches from Port Canning. The appendix masculina in the male develops only in prawns above 26 mm in length.

A bopyrid parasite infects about 10 per cent of the prawn population. The gonads of the infected prawns are obliterated and the animals appear stunted. A tentative suggestion is made regarding the probability of sex reversal as an effect of parasitism.

The dominant size group of *L. styliferus* constituting its fishery is the 45 to 66 mm. class. The rate of growth of the species appears to be about 3 mm. per month during the early period of its life.

These prawns support an important fishery at Port Canning, Diamond Harbour, Falta and other estuarine areas of West Bengal. The main fishing devices employed to capture them in the lower stretches of the Gangetic delta are briefly described. About one-fifth of the total catch of prawns at Port Canning, Diamond Harbour and Falta is constituted by the two important species of *Leander*, viz. *L. styliferus* and *L. tenuipes*, which are very often found together.

Possibilities of large scale culture of these prawns in the numerous brackishwater *bheris* of West Bengal are indicated. A suggestion is made regarding the advisability of extensive fishing in the river mouth areas for fishing the large-sized and berried prawns which are more in demand.

Acknowledgements :

I am grateful to Dr. B. S. Bhimachar for his encouragement and the interest shown in this work. My grateful thanks are due to Mr. T. V. R. Pillay and Miss K. K. Sarojini for their helpful suggestions and improvements made in the manuscript, and to Mr. K. H. Sujansinghani for the help rendered in the analysis of the length-weight data.

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TABLE V

Length frequency distribution of *L. styliferus* collected from Port Canning

Class range (mm.)	Mid-point (mm.)	1953										1954									
		June		July		August		October		November		January		February		March		April		May	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
26-28 —	27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	5	—	—	—	—
29-31 —	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13	5	2	3	—	—
32-34 —	33	—	—	—	—	—	—	—	1	—	—	—	1	—	—	9	6	3	7	—	—
35-37 —	36	—	—	—	—	—	1	—	0	—	—	2	2	—	—	21	15	4	8	—	—
38-40 —	39	—	—	3	1	4	1	3	5	2	1	3	3	1	3	19	22	9	5	—	—
41-43 —	42	2	—	6	3	13	10	4	14	4	10	7	26	4	8	22	14	8	10	2	—
44-46 —	45	7	—	6	4	14	11	5	10	10	6	22	45	12	23	27	27	20	8	4	—
47-49 —	48	4	1	5	3	25	22	6	4	6	5	27	40	22	25	33	32	33	16	9	1
50-52 —	51	8	7	7	2	27	23	11	9	4	6	27	39	26	25	34	43	60	28	4	5
53-55 —	54	3	12	7	3	23	15	16	8	9	7	25	42	9	21	24	27	72	39	13	8
56-58 —	57	6	9	4	4	18	19	25	12	18	13	25	34	5	13	29	48	80	50	15	4
59-61 —	60	10	11	1	4	15	20	17	14	27	18	19	34	0	5	21	31	46	35	11	10
62-64 —	63	3	15	0	2	19	11	16	15	27	24	13	13	2	2	8	32	37	47	13	17
65-67 —	66	0	6	1	2	20	31	3	9	10	16	5	9	—	1	7	20	18	50	3	5
68-70 —	69	0	5	1	4	11	26	—	2	2	9	5	5	—	0	6	24	4	32	0	5
71-73 —	72	1	6	—	3	1	19	—	0	—	3	4	2	—	0	1	18	1	33	0	3
74-76 —	75	—	1	—	1	—	8	—	1	—	1	0	2	—	0	0	5	—	22	2	6
77-79 —	78	—	3	—	—	—	1	—	—	—	—	1	2	—	—	2	2	—	4	1	4
80-82 —	81	—	1	—	—	—	—	—	—	—	—	1	0	—	—	1	3	—	2	0	0
83-85 —	84	—	0	—	—	—	—	—	—	—	—	1	1	—	—	1	—	—	1	1	1
86-88 —	87	—	0	—	—	—	—	—	—	—	—	1	0	—	—	—	—	—	1	—	—
89-91 —	90	—	1	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—
Total for each sex —		44	78	41	36	190	218	106	104	119	119	189	301	81	126	284	379	397	401	78	69
Total for the month (both sexes) —		122		77		408		210		238		490		207		663		798		147	

TABLE V

Length frequency distribution of *L. styliferus* collected from Port Canning (*continued*)

Class range (mm.)	Mid-point (mm.)	1954										Total Males		Total Females	
		June		August		September		October		November					
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Number	Percentage	Number	Percentage
26-28 — —	27							2	1			8	0.18	6	0.14
29-31 — —	30				2			0	0			15	0.35	10	0.23
32-34 — —	33			5	5		1	0	1		2	17	0.39	24	0.55
35-37 — —	36			8	10	5	8	3	2	2	2	45	1.04	48	1.11
38-40 — —	39			9	7	11	10	5	3	7	3	76	1.75	64	1.48
41-43 — —	42			14	10	13	16	9	15	5	9	113	2.61	145	3.35
44-46 — —	45			4	6	17	37	19	15	8	29	175	4.04	221	5.10
47-49 — —	48		2	4	4	21	40	9	11	11	18	215	4.96	224	5.17
50-52 — —	51	5	1	1	0	25	35	19	18	10	32	268	6.18	273	6.30
53-55 — —	54	9	2	0	1	11	33	15	14	10	30	246	5.68	262	6.05
56-58 — —	57	5	4	0		8	16	6	20	4	17	248	5.72	263	6.07
69-61 — —	60	13	9	1		1	8	5	4	4	15	191	4.41	218	5.03
52-64 — —	63	10	7			3	5	4	4	1	5	156	3.60	199	4.59
65-67 — —	66	7	8				0	0	7	1	5	75	1.73	169	3.90
68-70 — —	69	2	11				2	0	0			31	0.72	125	2.88
71-73 — —	72	1	1				1	1	0			10	0.23	89	2.05
74-76 — —	75	0	5				1	1	0			3	0.07	53	1.23
77-79 — —	78	1	4						1			5	0.12	21	0.48
80-82 — —	81	1	0									3	0.07	6	0.14
83-85 — —	84	0	1									3	0.07	4	0.09
86-88 — —	87	1	1									2	0.04	2	0.04
89-91 — —	90											1	0.02	2	0.04
Total for each sex	—	55	56	46	45	115	213	98	116	63	167	1,906	43.98	2,428	56.02
Total for the month (both sexes)	—	111		91		328		214		230					

13

AWN CULTURE IN THE RICE FIELDS OF TRAVANCORE-COCHIN, INDIA

by

K. Gopinath*

scale culture of prawns in the rice fields is a practice in certain north-western districts ancore-Cochin State, India. This method unusual and does not seem to be carried on xtent in any other part of India, although it is in certain other countries of the Indo-Pacific especially in Indonesia and the Philippines.

ractice of growing prawns in rice fields on a cial scale has formed an important part of ng industry of the State for many years past. thod, which originated a few decades ago in ges bordering the sea to the north of Cochin has now developed into a major industry about 10,000 acres of fields spread over a a. The magnitude of the industry can be n Table I which gives the annual export of awns from Travancore-Cochin. This may be attributed to the peculiar topography of thern region with its extensive brackish-ones, associated with low-lying rice fields ntricate network of canals and small streams.

TABLE I

in hundredweights of dry prawns exported from the State, 1952 to 1955.

	1952-53 Cwt.	1953-54 Cwt.	1954-55 Cwt.
..	221	6,812	3,315
..	6,470	9,349	8,616
..	1,640	5,826	7,659
..	13,667	9,661	8,120
..	4,886	9,515	3,569
r ..	7,691	12,895	8,530
..	6,697	9,804	6273
..	5,022	3,882	4,631
..	5,884	5,447	4,760
..	2,511	10,047	7,399
..	10,376	5,911	7,464
..	7,689	6,654	6,261
Total ..	72,718	95,803	76,597

ar (1937) gave an account of this fishery, the fishing methods and the processing industry, and the same author (1952) also stressed the need for developing this method in other parts of the country. Recently, Menon (1955) by experiments in a prawn pond calculated the yield per annum of the various species which constitute the fishery. The present paper deals in detail with the distribution and disposition of the prawn fields, their ecology, the preparation of the fields, various methods of fishing and also the dressing of the fields immediately after the prawn season as a preliminary step to the sowing of the new rice crop.

The Prawn Fields

Distribution and acreage

Unlike the central and southern districts of the State where there are two rice crops each year, the rice fields of the north-western area, commonly known as the *pokali* fields, are cultivated only once a year, from June or July to October. For the rest of the year they remain uncultivated, and it is during this period that the prawn culture operations are carried on. Thus, as has been suggested by Hora (1951), it signifies an alternate raising of two different crops on the same land and can be included under the second category of fish culture i.e., fish rearing as a secondary crop, as defined by Hofstede and Ardinawata (1950).

Prawn culture in this State is carried on principally in the Taluqs of Cochin-Kanayannur, Parur, Crangannore, and Vaikom bordering the Vembanad Lake, and from 8,000 to 10,000 acres of rice fields are utilised each year for this purpose.

Cochin Kanayannur Taluq lying on the northward extension of the Vembanad lake and east of Cochin bar, has about 35,000 acres of rice fields, 13% of which, especially the low-lying fields to the west of the lake and north of the bar, is used for prawn cultivation. This Taluq has probably the largest acreage under prawn cultivation in the State (Table II). In Parur Taluq, east of the northward extension of the lake and south of the outlet of the Periyar river, 9.8% of the 33,000 acres of rice fields are used for prawn rearing. Vaikom Taluq, east of the southward extension of the lake, has about 25,000 acres of rice fields, of which only 1.5% consisting of fields lying close to the backwater, are utilised for this industry. Shertalai Taluq west of the lake and opposite to Vaikom has only very recently taken to this method and has the least acreage of prawn fields.

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* Director of Fisheries, Travancore-Cochin State, Trivandrum, India.

The prawn-rearing rice fields are classifiable i three groups. Those which lie adjacent to the ba waters where the tidal influence is maximum are most productive and are in the first class ; the seco class are those which are farther away from the la but are intersected by brackishwater canals which turn are influenced by the tides ; while the fie lying still farther away from the lake but which are still in the neighbourhood of brackish water canals constitute the third class. This classification constitutes the basis for assessing the nominal fee per acre which is levied by the State Government. The average annual income from this source over the past few years has been about 20,000 rupees.

TABLE II

Acreage under prawn cultivation

Taluq	1949-50 Acres	1950-51 Acres	1951-52 Acres	1952-53 Acres	1953-54 Acres
Vaikom ..	102.83	218.79	302.84	352.36	388.20
Parur ..	1,664.08	2,556.00	2,998.00	3,199.04	9,000.00
Cochin-Kanayannur ..	2,637.80	3,391.27	4,597.73	4,604.23	
Mukundapuram Crangannore ..	235.01	327.58	956.28	971.22	815.56
Total ..	4,639.72	6,493.64	8,854.85	9,126.85	10,203.76

Topography.

The *Pokali* fields in Cochin-Kanayannur, Parur and Crangannore Taluqs, which lie in the close vicinity of the backwaters and usually only at a slightly higher level than the lake, mostly fall into the first two categories. Vaikom, on the other hand, has the majority of its prawn fields away from the backwaters, with coconut plantations in between. These fields are connected with the backwater by a number of tidal canals, and are consequently in the last two classes. Shertalai Taluq which is predominantly a sandy area has a few low-lying fields at its northern border. These are situated on the banks of narrow branches of the backwater and are connected to the main body of the lake by canals. Here also only the last two classes of fields are represented.

The single crop of rice in these fields is raised from June or July to October, which coincides with the freshwater season which occurs after the south-west monsoon and before the north-east monsoon. During this period, the backwaters are in a flooded condition and the water is therefore absolutely fresh, except at the confluence of the lake with the sea. By October, when the rice has been harvested, the secondary maximum rainfall of the north-east mo soon causes a second flooding, and the paddy fi remain submerged and in direct communicat with the backwaters and canals. After the no east monsoon the water level in the surroun backwaters falls and it is at this period that the pr liminaries of the cultural operations begin in fields.

In November, when the rains are over, there is flow in the canal systems adjoining the lakes a fields and the water becomes more and more brack as the result of tidal influence. The tidal rang which is of great importance in prawn culture, var from place to place. It is maximum in places li Ezhikara, Varapuzha, Chathanad and Narakkal Parur and Cochin-Kanayannur Taluqs situated b ween the Munambom bar on the north and t Cochin bar in the south. Here, the tidal range reported to be more than 2½ feet and the ebb ti are marked by very strong currents. This tide also maximum in the low-lying reclaimed fie which are connected with the backwaters o through canal systems. In Vaikom Taluq, wh the fields are farther inland, the tidal range is smal while in Shertalai Taluq it is minimum.

Table III

Lowest water level	0.33′
Average low water level ..	1.00′
Mean water level	2.00′
Average high water level ..	3.00′
Highest water level	4.08′

and Subsoil.

ng the rice cultivation period, the water in the and adjoining backwaters is almost fresh, h the latter may show some slight salinity. August, towards the end of the rice culti- period, analysis of the water in the field 6.8 p.p. 100,000 of chlorides while the water e adjacent backwater showed a chloride con- 18.8 p.p. 100,000. With the cessation of the flowing from the canals and the greater in- of the tides, the salinity gradually increases, the backwater and in the rice fields, although ht difference between the fields and the back- persists until March-April, when the salinity its maximum for both fields and backwaters 3,200 p.p. 100,000). Subsequent to this, he bunds in the fields are permanently closed ater remains almost stagnant, the salinity the fields shows a slight increase due to ation.

bottom of these prawn fields consists mostly with a mixture of fine sand. This loamy subsoil is characteristic of the whole area, portion of sand and mud varying from place e. In the Taluqs of Parur and Cochin nnur, east of the backwater, the bottom soil greatest mud content with less sand, while ion west of the lake has a greater percentage of an mud. Vaikom and adjoining areas have an equal proportion of sand and mud while rtalai taluq the subsoil has the greatest sand . All the fields also have a very large per- of organic matter caused by the decaying of straw and other plant residues.

planktonic organisms in the fields show ns according to the salinity of the water in ds. The principal organisms are small cope- rustacean larvae, fry of some of the estuarine ke *Ambassis* and a large quantity of algae with mixture of freshwater and marine diatoms. ttom organisms are principally small poly- worms, both free living and tubicolous and types of lemellibranchs, as well as adult and prawns.

ation of Fields

the rice is harvested in September, water e backwater is permitted to flow freely in of the fields. At the end of the north-east n floods, usually by the last week of October, liminaries of prawn culture begin. In some owever, this takes place only by the end of ber when the level of water in the lakes has o recede. The first step is the preparation lock for cultural purpose. Ordinarily the ds are small holdings with an area of only a es. As prawn culture in such small fields is not economical, a very large number of fields lying together in an area is converted into a single block and taken on lease from the owners for the prawn culture operations. Such a block may vary in size from 10 acres to 900 acres.

After a block has been selected, surrounding bunds are strengthened. A block surrounded on one or two sides by raised dry land may need only one or two bunds. When two blocks lie contiguous, a secondary dividing bund would also be necessary, but whereas the former type of bund is a somewhat massive structure, 5 to 6 feet high, with a bottom width of 15 feet and a top width of 12 feet, the secondary bunds are smaller, having the same height as the primary ones but with a bottom width of only about 8 feet and a top width of about 4 feet. About four feet of water is always retained inside the field, during the highest tide.

Ordinary mud is used for the construction of the bunds. Stakes are first driven into the ground in two rows at the required width and the sides covered with coconut leaf mats or wooden planks. The space thus made is then filled in with mud and clay dug out from the neighbouring lakes. Large quantities of water-grass and twigs of plants also go into the construction as strengthening materials.

In some places, especially along the edge of the backwaters where the strong winds and waves are likely to destroy the ordinary mud bunds, mud and laterite stones are used to make the bunds a quasi-permanent structure. Here, the sides of the bunds are lined with laterite stones. In some cases where the bunds have become a permanent feature, the sides are simply lined with rubble or the rubble may be pointed and strengthened with cement. Such permanent and quasi-permanent bunds may even be planted with coconut palms which provide both shade and reinforcement.

The secondary bunds dividing the blocks from one another are invariably made of mud or clay.

Sluices are inserted in the primary bunds to regulate the flow of water from and into the fields. The whole sluice is a rectangular, hollow, box-like structure with the short ends opening into the field inside and into the backwater or canal outside. Its four sides are ordinarily made of planks fixed to strong wooden frames with the smooth surface facing inward. Sometimes only the sides and bottom are planked, the top being simply a frame.

The sluice generally measures 15 feet in length by 6 feet in width and about 9 feet in height. The sluice is 2 to 3 feet higher than the level of the bund and as its length coincides with the bottom width of the bund and since the width of the bund at the top is only 12 feet, the ends of the sluice project about

1½ feet on either side. Unlike the sluices in the Bangos fish ponds of the Philippines, no aprons are used at the two ends.

At the centre of the sluice or slightly towards the outside opening, two verticle grooves are provided on the side-walls into which slide a number of ¾″ or 1″ planks one on top of the other, to regulate the flow of water. On the inner side of this wooden sluice gate, there may also be a removable partition made of close-meshed bamboo trellis work or matting. This is intended to keep the prawns escaping from the fields when the sluice gates are opened for letting in water.

The number of sluices will vary with the acreage of the fields (a single sluice being considered sufficient, for a ten acre block) but the size of the sluice will vary little from the above dimensions. Since the capture operations take place at the point of outflow, it is desirable to have the smallest possible number of sluices. In blocks of less than ten acres, the sluices may be smaller in size, but the plan of construction remains the same.

The fishermen's hut containing all the fishing implements is generally located on the bund, by the side of the sluice, as constant attention to the regulation of water flow is essential during the fishing operation.

Fishing Operations

Three types of prawn fishing operations may be recognized. The normal type of fishing which ends by the middle of April, has been described both by Panikkar (*op. cit.*) and Menon (*op. cit.*). The net used in this fishing is a bag 20 to 25 feet in length with a 6′ × 6′ or 6′ × 5′ mouth and a 1′ × 1′ tail. It is made up of 10 sections, the section at the cod end having a mesh size of ⅛″, the next seven sections a ¼″ mesh, while ½″ mesh is used for sections 9 and 10. About 15 hanks of No. 20 yarn are required for the making of such a net. In smaller fields with smaller sluices, a net of about 18 or 20 feet long with 8 sections is used.

The second type of fishing is carried on in some of the fields for two or three months after the rice is sown. It is mainly practised in the Taluqs of Parur and Cochin-Kanayannur and usually extends from the latter half of July to the middle of September. During this period the water, both in the fields and the lake, is almost fresh and while there is not much difference in the water levels there is a strong current during low tide because of the general high water level in the lake. The method of fishing is almost the same as in the normal operation, except that during high tide the water is freely allowed to enter the fields. The water being almost fresh the catches during this period are somewhat less.

While the above are the more usual procedure prawn fishing is also carried on in fields without such elaborate arrangements. In smaller holdings and where it is not economically possible to convert a number of fields into extensive blocks, fishing is done during the proper season by merely using a net tied to two poles which are driven in at any breach in the field bunds during low tide. Although this type of fishing is not so efficient as the normal process with bunds and sluices, its yield is considered to be better than that from the secondary fishing carried on during the rice growing.

A few years ago about 300 acres of low-lying land near the sea in Edavanakad village in Cochin-Kanayannur Taluq were subject to severe sea erosion and became waterlogged and unsuitable for rice growing. These areas have therefore been converted into permanent prawn culture fields, where prawn fishing operations are carried on throughout the year. The area is divided into suitable blocks bunded and fishing carried by the normal process mentioned above.

Species and Yield

Nataraj (1942) in his report on the prawn fauna of Travancore described seven or eight species of prawns commonly occurring in the backwaters and stated that *Metapenaeus affinis* and *M. dobsoni* constitute the bulk of the catches from the rice fields. Menon (1955) listed eight species, the most important of which were *Metapenaeus dobsoni*, *Penaeus indicus* and *M. monoceros* in the order of their abundance. *M. affinis* mentioned by Nataraj is reported to be very rare in the catches so that it can safely be ignored in enumerating the species caught from the fields.

The yield of prawns per acre varies from place to place and is highest in the Taluqs of Parur and Cochin-Kanayannur, particularly in those regions lying on either side of the lake between the Munambom Bar to the north and Cochin harbour to the south. This is attributed to the nature of the local sub-soil and the favourable tides owing to the two confluences with the sea.

The average yield per acre from an A class prawn field amounts to 6 maunds (180 lb.) of dry prawns which is equivalent to 1,080 lb., of prawns wet weight, though Menon has mentioned the yield as varying from 106 to 294 lbs. of dry meat. The yield from a B class field is calculated to be 3½ maunds of dry prawns or about 630 lbs. of fresh prawns and that from the C class 2 maunds (60 lbs.) of dry prawns or 360 lbs. of fresh prawns. The yield from the A class field almost equals that mentioned by Schuster (1952) but much less than the yield from the Singapore prawn ponds (Burdon, 1953), although the average yield from the latter ling to Tham Ah Kow (1955) was only 545 lbs. is slightly less than that of the Travancore B rawn fields.

m December onwards, a gradual increase in eld is noted, with a maximum during April, the onth of the season. The strong tidal current the latter months and the natural growth of the prawns contribute to this enhanced yield. Also, fishing operations are likely to be more intensive during the last month so as to catch all the remaining prawns and then prepare the field for cultivation.

Table IV and V give the yield from certain fields in the Parur and Cochin-Kanayannur Taluqs respectively.

TABLE IV

Yield from certain prawn fields in Parur Taluq

Locality & Village	Area in acres	Class	Yield in lb. (Wet weight)				
			Dec.	Jan.	Feb.	Mar.	April
parur) —	9.40	A	1,680	1,260	2,752	3,300	4,420
zha —	13.50	A	1,500	1,400	3,100	3,700	5,120
alli —	28.50	A	3,500	5,450	8,670	9.050	9,530
a —	22.64	A	2,100	3,210	5,770	7,675	9,370
—	7.28	B	400	700	1,010	1,250	1,500
chira —	5.72	B	..	300	700	1,100	1,430
	8.00	C	..	280	430	880	1,250

TABLE V

Yield from certain prawn fields in Cochin Kanayannur Taluq

Locality & Village	Area in acres	Class	Yield in lb. (Wet weight)				
			Dec.	Jan.	Feb.	Mar.	April
—	19.90	A	3,820	4,192	4,780	5,100	5,218
l —	33.00	A	6,200	6,820	7,380	7,905	3,123
ad —	13.80	A	1,826	2,220	3,100	3,200	3,800
am —	23.63	B	2,160	2,210	2,800	3,600	3,780
—	24.10	B	1,860	2,400	2,880	3,200	3,680
am —	18.00	A	3,240	3,456	3,900	4,365	4,805
am —	10.20	B	963	1,028	1,260	1,490	1,628
d —	11.32	C	680	782	900	1,036	1,180

ultural Treatment of Fields

the middle of April, when prawn fishing is he fields are drained and dried. For this, the nside the field is let out through the sluice low tide and the gates closed at the commence- f the high tide to prevent the entry of water. ge is facilitated by the low level of water in at this time of the year. By repeating this for two to three weeks the water is gradually off until only a few inches remain and the then permanently closed.

the level of water has thus been lowered e field, the earth is raked up and heaped into nounds of about two feet in diameter and h. The field is then allowed to dry in the a period of two or three weeks until the ncement of the monsoon rains which leach out the salinity from the mounds into the surrounding water in the field. As much of this water as possible is again drained off during low tides. As the rain increases towards the middle of June the level of water in the fields rises and salinity decreases until, when the level has reached up to a few inches below the top of the mounds, only traces of salinity remain and sowing of the rice plants commences. This is usually done on the top of the mound after flattening it a little so that the seedlings remain above the level of water.

The strain of rice used is slightly salt resistant, and by the time the seedlings have grown to a height of 6 to 9 inches the water will have become almost fresh. The seedlings are then transplanted, at which time the mounds are raked up and spread out and the seedlings uniformly planted over the fields.

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14

CULTIVATION OF ‘SUGPO’ (JUMBO TIGER SHRIMP), *PENAEUS MONODON* FABRICIUS, IN THE PHILIPPINES

by

M. N. Delmendo and H. R. Rabanal*

The cultivation of the ‘sugpo’ (jumbo tiger shrimp), *Penaeus monodon* Fabricius, has become an important and lucrative undertaking in estuarine fishponds. In the Philippines, juveniles of this species rank next to *Chanos* fry in market demand and value compared with other salt water stocking material. ‘ Sugpo ’ are caught in almost all places where *Chanos* fry are collected but they appear at a somewhat later period.

Among the species of commercial shrimps of the genus *Penaeus*, *P. monodon* is the most highly esteemed by the consumers. Being considered a table delicacy it commands the best price whenever present in local markets. A kilogram of marketable ‘sugpo’ costs from five to eight pesos** whereas other shrimps like the ‘hipon-suahe’ (*Penaeus canaliculatus*), ‘hipon-puti’ (*Penaeus indicus*) and ‘hipon-culot’ (*Penaeus* sp.) cost from two pesos to five pesos per kilogram.

Shrimps, when present in fishponds in addition to the cultivated species, are found to be harmless to the main crop of cultivated milkfish. Further they provide an additional income to the culturist Hence it is that ‘sugpo’ are deliberately gathered and stocked in the ponds to be grown to a marketabl size.

The production of *Penaeus* in estuarine fishpond in the Philippines resulting from the normal shrim population that enter the pond during the cultivatio period is estimated to range from 50 to 200 kilogram per hectare per year. If, however, in addition to thi normal stock, ‘sugpo’ fry is introduced into the pond shrimp production per hectare per year may b raised to 500 kilograms of which about 70 per cen may consist of *P. monodon*.

In spite of the promising aspect of the shrim culture industry, scientific studies along this lin are still meagre. The present paper embodies th results of an attempt to study the rate of growth o ‘sugpo’ in ponds, with notes on some problems an the technique of its cultivation in the Philippines The study was undertaken at the Dagat-dagata Salt Water Fishery Experimental Station, Malabon s, Rizal Province, Luzon, and covered the s of September 1943 to April 1944 and nber 1950 to August 1952.

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* Bureau of Fisheries, Manila, Philippines.

** Two pesos equal One U.S. dollar.

po' fry bought from dealers in addition to those ed in the Dagat-dagatan lagoon were stocked nurseries of the Bureau of Fisheries at Dagat- n. Weekly samples were taken and measured ne time they were stocked in the nursery ponds hey were transplanted to the bigger rearing and monthly measurements of samples from atter ponds were subsequently made. Sampl- e nursery ponds was effected by using fry r 'bon-bon'. When the 'sugpo' abandoned its g habit, sampling was made by random catches d or by traps.

juvenile 'sugpo' is dark brown to almost black ur. The body is firm and straight when un- ed in the water and could easily be mistaken nall fragment of stick or debris. The physical s of a young 'sugpo' are similar to those of a one except that the body colouring changes in urse of growth. The fry is dark blackish, opaque, while the bigger size is dark blue- and somewhat translucent.

'sugpo' fry (Fig. 1) caught from the fry grounds ed on the average 15.3 mm. in total length, n. in body depth and weigh 0.025 grams.

ough the shrimps were subsequently carefully ed and weighed at monthly intervals, their uent growth cannot be said to show any ive results as there was considerable varia- uring the three periods of observation (as s one order of magnitude during the earlier). Moreover, the experiment was carried twelfth month during the 1951-1952 season The average figures shown in Table I are, re, for the present given merely as a rough s to the approximate sizes likely to be en- ed at monthly intervals after capture. The

TABLE I

Average Rate of Growth of *Penaeus Monodon* under Cultivation

Duration of Culture	Total length (mm.)	Body Depth (mm.)	Weight (g.)
Fry ..	15.3	1.6	0.025
One week ..	21.5	2.5	0.06
Two weeks ..	28.2	3.6	0.08
Three weeks ..	38.8	4.5	0.92
Four weeks ..	45.3	5.7	0.78
Five weeks ..	57.1	7.8	1.63
Six weeks ..	60.3	9.7	3.39
Seven weeks ..	69.5	10.9	4.36
Two months ..	79.0	9.8	4.34
Three months ..	94.7	11.1	6.88
Four months ..	120.0	15.3	14.5
Five months ..	Incomplete		
Six months ..	141.9	18.3	22.3
Seven months ..	152.6	16.4	25.1
Eight months ..	Incomplete		
Nine months ..	178.0	27.8	57.3
Ten months ..	211.6	30.2	62.8
Eleven months ..	223.0	32.0	70.7
One year ..	229.8	32.0	95.1

Note.—The data for the ninth to twelfth months are for the 1951-52 season only and are therefore not strictly comparable with averages for the earlier periods.

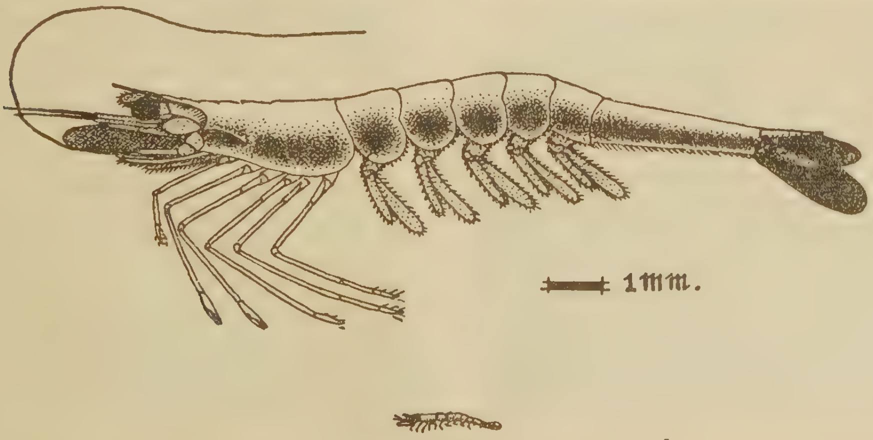

Fig. 1. The fry of 'sugpo', *Penaeus monodon*

exact age of the fry at the commencement of the experiments is not known.

It will be seen that the ‘sugpo’ which had been held in ponds for one year (Fig. 2) measured on the average 229.8 mm. in total length and 32.0 mm. in body depth and weighed 95.1 grams. The largest specimens of this age may, however, measure as long as 250.0 mm. weighing about 120 grams while others may be as small as 180.0 mm. long with a weight of 50 grams. A kilogram of one year old ‘sugpo’ may contain 8 to 20 individuals.

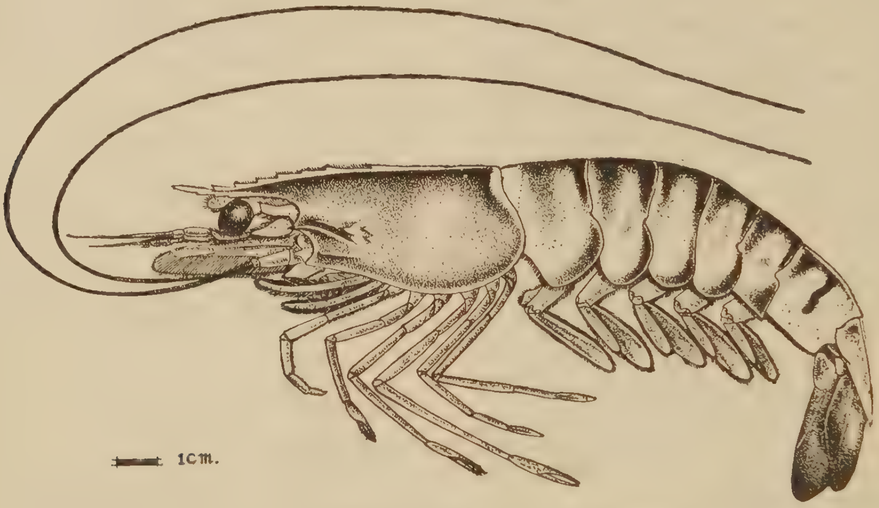

Fig. 2. A full-grown ‘sugpo’, *Penaeus monodon*

The ‘Sugpo’ Fry Industry :

It is probable that the ‘sugpo’ spawn in the sea, not far from the coast and that the young are carried to shallow coastal areas, tidal rivers and estuaries by the incoming tide. They also enter fishponds through the coarse screens of the water control gates, where they constitute a welcome and gratuitous addition to the cultivated fish crop. Not a few uninformed caretakers in fact regard the presence of these unstocked species in the ponds as ‘singaw’ or spontaneous products, because they pass through the gates unnoticed when small but later constitute a part of the harvest.

The ‘sugpo’ fry season begins in the month of May and extends up to October, the peak of the season occurring in August and September. The shrimp fry industry consists of the catching, sorting and distribution of the fry to fishpond centres. Unlike the *Chanos* fry industry, it involves very little investment. Chanos fry grounds are leased by the municipal government to individuals; ‘sugpo’, on the other hand, are gathered from the fishing grounds without any fee.

The fry are caught by lures from natural waters. These lures, locally called ‘bon-bon’ are made of bunches of small aquatic plants and grasses. The species most commonly used for this purpose is a salt water grass, *Paspalum vaginatum*. Bunches of this grass are tied to form circular pieces, which in turn are tied to a long line of string, rattan or wire, and then set in the fishing ground. These lines of lures are tied at intervals of ten to twenty metres to lines of bamboo or wooden poles near the bank. Several such lines can be set in a tidal river or stream provided they do not obstruct the passage of small craft.

From a wooden dugout or ‘banca’ the collector gathers the fry by means of a dip net. They are then scooped up with a white porcelain bowl and transferred to an earthen jar. Collection is made twice or more at any time of the day, regardless of weather and tide conditions. The fry are sorted during the collection so as to get rid of extraneous species and are finally distributed in earthen containers to fishpond owners, at a price of from one peso and fifty centavos to six pesos per hundred.

Raising.

There is no standard method of raising ‘sugpo in ponds. Fishpond operators in brackish and salt-water areas generally look upon shrimp cultivation as a supplementary source of income and seldom are special ponds set apart for this purpose. Fish or shrimp fry may be stocked exclusively in prepared ponds, or in nursery ponds used for *Chanos* or in the transition and rearing ponds, with or without previous preparation and with or without other species.

best results have been observed where the fry are stocked in previously prepared nursery The preparation of these nurseries for 'sugpo' tion is similar to that of *Chanos*, that is, by g, levelling, draining and drying the bottom.

po' fry are plankton feeders and so before g the nurseries, measures are taken to achieve riant growth of the micro-benthic biota or ɔ' asi n *Chanos* culture. Once this fish food developed in the pond bottom, the water is d and the nurseries are ready for stocking. ure type of culture the jumbo tiger shrimp is ly stock reared in the ponds. In a mixed the 'sugpo' fry are planted in a nursery pond sly stocked with *Chanos* fry. The stocking ty is highly variable depending on supply hectare of nursery may accommodate as many fry as 'bangos' (*Chanos*) fry, or say about o. Care is taken to see that the shrimp are l later than the *Chanos* to avoid predation.

n the case of *Chanos* the ponds are stocked the cooler part of the day and the conditions water in the jar are first approximated to f the pond water to be stocked. After stock- nurseries, little care is needed and rearing is to occasional renewal of the pond water, ining algal growth in the pond or giving l feed in the form of rice bran.

proper care and enough food for a period ne to two months the 'sugpo' attain a size h they may be transplanted from the nurseries bigger rearing ponds. Some difficulty is tered in effecting such transfer because they in the soft, muddy bottom. Two methods nsplanting are generally adopted, namely, pping, and (b) draining.

ne first case, shrimp traps made of bamboo or 'baklad' are set in the pond bottom, utiliz- e same principles used in trapping fish in aters. There is a guide screen or leader, a mber and a catching chamber or cod end. e of the non-gregarious nature of the shrimps eir burrowing habits, only a fraction of the an be caught by this method so that in order t a total catch the pond is drained slowly, g the shrimps to seek shelter in the deeper s of the ponds. Once this stock has become rated in the deeper areas they are then d by hand for transfer to the bigger rearing

h the young 'sugpo' are sufficiently advanced e big enough to escape from their enemies, e stocked in the rearing ponds regardless time of day or the condition of the ponds. h better quality 'sugpo' may be produced when cultured alone by themselves, the general practice is to raise them with *Chanos* inasmuch as these two species are compatible. About 10,000 'sugpo' may be stocked per hectare of rearing pond.

Not much care is given to the 'sugpo' under cultivation in the rearing ponds and with enough food they are expected to attain marketable size in a period ranging from six months to one year.

Cropping:

Unlike *bangos* which are easily caught by nets or confined by renewal or draining of the water, marketable sugpo are harder to catch. This is because the shrimp usually move around individually and are burrowing in habit. In fact, some loss occurs on account of this both during transplantation from one pond to another and when harvesting marketable 'sugpo' from the rearing ponds, although several means are employed to minimize such losses. Methods of capture by hand, by bamboo traps, by nets and by draining, are described in the following paragraphs.

(*a*) Bamboo screen traps.—Varied types of screen traps are used in harvesting 'sugpo.' These traps utilize the same principle as ordinary fish traps encountered throughout the Indo-Pacific region. Essentially, they consist of a guide screen or leader and a cod end or catching chamber. An example of one such trap is the 'bakikong' as shown in Figure 3. The leader of this trap consists of one or two bamboo screens staked and oriented perpendicularly or diagonally from the pond dike. This leads the shrimp to a fore chamber from which the shrimps are led into the cod end or catching chamber. These traps are specially effective during dark nights, particularly if there is water movement caused by renewal or draining. The catch is enhanced by installing a light in the catching chamber at night. The catches consist mostly of 'hipon suahe' (*Penaeus canaliculatus*). They may also include 'sugpo' if present but rarely hipon-puti (*P. indicus*).

Another type of bamboo screen trap is the *paabang* (Fig. 4). This is set so as to intercept the shrimp at some narrow gap in the fishpond system. It consists essentially of the catching chamber which is centrally and posteriorly located and two wings to screen the water passage. These traps are more effective during dark nights and when strong current of water can be made to flow through the passage where they are set. The main catch may be *P. canaliculatus* and possibly *P. monodon* if present, but rarely *P. indicus*.

A third type of bamboo screen trap is called the 'aguila.' This is a modification of the 'bakikong' consisting essentially of a leader which is comparatively longer than that used in the 'bakikong' and two

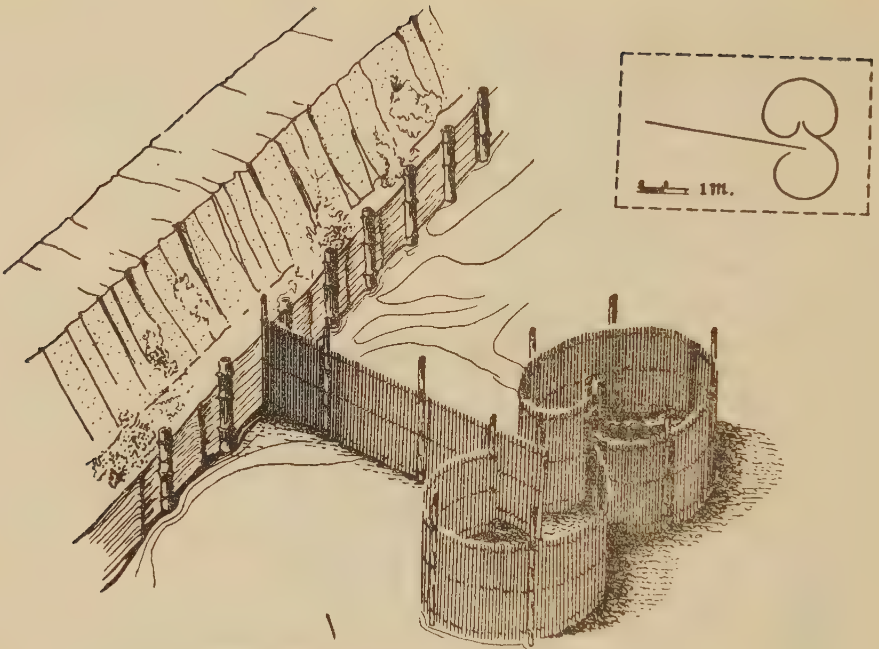

Fig. 3. The 'bakikong' type of bamboo screen shrimp trap

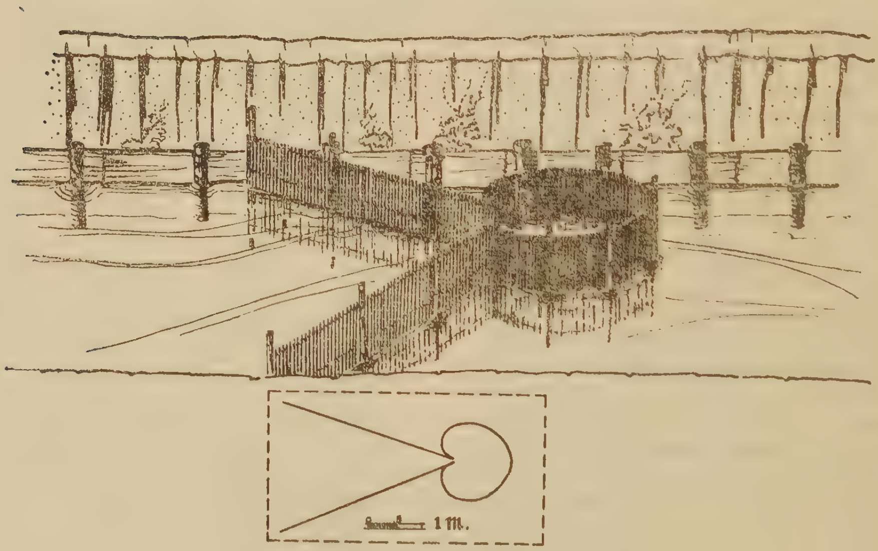

Fig. 4. The 'paabang' type of bamboo screen shrimp trap

chambers strategically located at both sides at the end of the leader, as shown in Figure 5. It is set in the deepest portion of the pond and is intended principally for catching *P. indicus*, although the catch may also include *P. monodon* if present. Although the catch is limited, it is more or less continuous regardless of the time of day or night, or whether the flow is regulated or not.

(*b*) Net traps.—A bag net of coarse cotton twine mounted on a wooden frame fitting into special grooves in the gate has come into general use in the cropping of shrimps in ponds. This net is called the 'lumpot'. It is a sort of bag net tapering to an open end which is closed at will by tying with a piece of string and is usually set at the main water control gate, the water being previously raised to

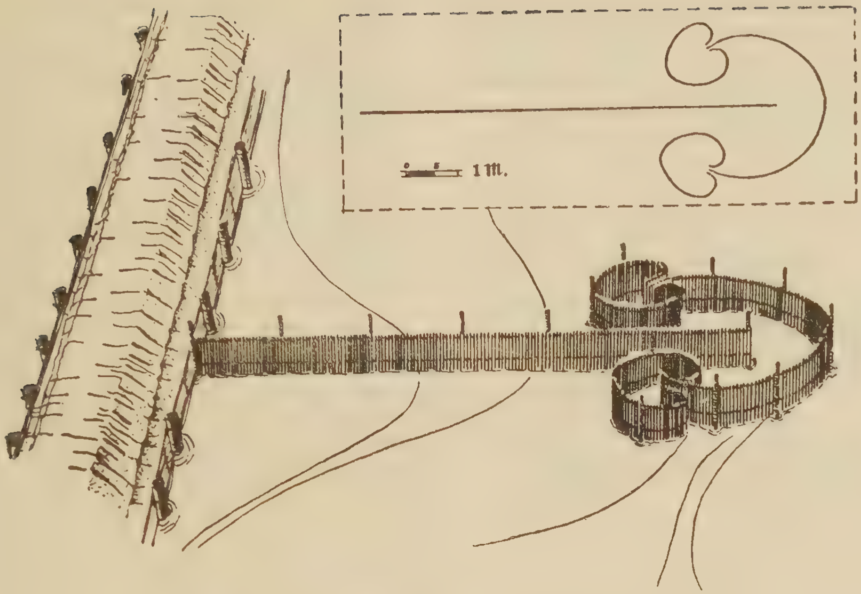

Fig. 5. The 'aguila' type of bamboo screen shrimp trap

ximum height at high tide. Thereafter, own the water is allowed to go out with rce. The current carries the shrimps to of the bag where they are collected from time by a man stationed on a dugout canoe.

ns of 'Sugpo' Cultivation :

o' cultivation, although very promising is ith innumerable problems which need to d in order to put this industry on a sound basis and make it a lucrative investment. the problems encountered in this industry

Difficulty of cropping.

Real or apparent low rate of survival under cultivation.

Uncertain and limited supply of stocking material.

ifficulty of cropping 'sugpo'.—Under culti- sugpo' is cropped twice, i.e. at time of trans- on and harvesting. There is considerable in accumulating a reasonable crop and in a total catch. This may be attributed to gregarious habits of the shrimps. Effective of capture have hence to be evolved.

w rate of survival.—The amount of market- gpo' recovered from ponds where they were ly stocked has been found to be very low. mated rate of survival in ponds ranges from 50%. This may be due to predators, mortality or the non-recovery of those shrimps which bury themselves in the soft, muddy bottom.

3. *Uncertain and limited supply.*—Perhaps the most important factor limiting the production of 'sugpo' in ponds is the uncertain and limited supply of the juveniles for stocking purposes. The season for catching 'sugpo' fry varies from year to year and the supply fluctuates considerably. There has been no systematic survey of actual and potential fry grounds except in places where they are incidentally found with the 'bangos' fry. Even if there is a supply of fry, the price is often exorbitant and the tiny needle-like fry costs from two to six centavos each whereas *Chanos* fry may cost 0.2 centavo a-piece. Around the Manila Bay area most of the tidal creeks produce a limited supply of 'sugpo' fry each year, and the towns bordering the Bacoor Cove along the Cavite Coast constitute a regular source of supply of 'sugpo' fry to the fishponds in this area where the fry catching has developed into a special trade.

Layout, Construction and Management of a 'Sugpo' Pond Project

A 'sugpo' pond project can be established at any suitable place where adequate stocking material is available. For instance, a 10-hectare swampy area along a tidal stream, if falling within the tidal range and more or less level, with good clay loam or sandy clay loam soil and moderately clear of vegetation may be utilized. The area may be enclosed (Fig. 6) by strong main dikes high enough to keep off tidal water and flooding by freshets. A concrete main water control gate (Mg) of double-opening type may be provided at a point easily accessible to the main portion. This may open to a head pond (hp) which should be the deepest portion of the system. This pond should lead to two secondary gates (sg) which in turn lead to the two rearing ponds (rp) and there will be a water control system leading to the nursery catching ponds. The nursery unit, one hectare in area, should be located immediately in front of the head pond, away from the main water control gate and it should be shallower than the rearing ponds.

A secondary dike, constructed in line with the main water control gate, would bisect the main area into two main parts, each with a large rearing pond and a nursery catching pond. Such a layout is deemed very convenient for transplanting the stock because the growing 'sugpo' from each nursery can be easily transplanted by simply breaking—opening the dike to the adjacent rearing pond. At the outset, the entire fishpond system should be so levelled that the bottom will gradually slope from the periphery of the pond system to the head pond and the main water control gate. Then a system of special depressions or canals are constructed in each nursery and rearing pond running from the periphery towards the nursery and secondary gates respectively, as indicated in Figure 6, so as to facilitate harvesting.

Once established, the unit may conveniently be stocked with 'sugpo' from 300,000 to 500,000 fry per crop, first in the nursery ponds for a period of one to two months for subsequent release in th rearing ponds. Of these fry, about 20% ma be expected to survive, leaving an expected cro of about 100,000 marketable shrimp equivalent t about 5,000 kg, valued at P.15,000 (based on a wholesale price of P.3.00 per kg). Two crops a year, crops in two years or one crop a year may be reared

The nurseries may be stocked again after eac transplantation after a minimum period of preparation.

The desirable food organisms may be develope in the ponds by proper management. While th plan has been deduced from observations of a mix

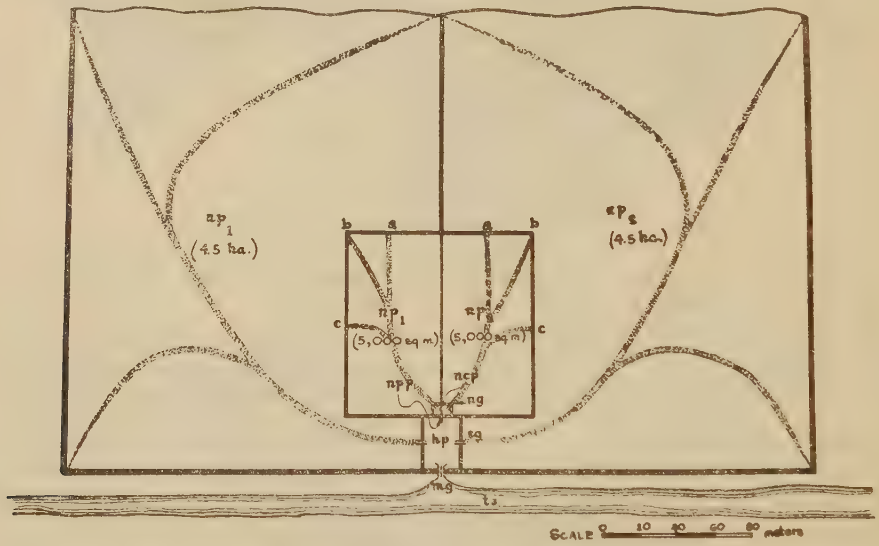

Fig. 6. Model layout for a 10-hectare *Penaeus* pond project

culture of '*sugpo*' and milkfish, such a plan could b adopted in any experiment to find the possibilit of pure culture of *Penaeus*. At present, a few the more progressive *Chanos* fishpond growers i the Philippines are actually practising this syste to a limited extent.

Summary and recommendations

1. The cultivation of the 'sugpo' in estuarin fishponds in the Philippines either as pure culture o in combination with *Chanos* is found to be a lucrativ investment.

2. In order to minimize the losses due to th difficulty of collecting all the growing 'sugpo' in the nurseries, it is recommended that the nursery pond should be located adjacent to and at a slightly highe level than the rearing ponds where the 'sugpo' ar to be grown to marketable size. In this way transplantation is effected by simply making a cu in the dike between the nursery and rearing pon

he 'sugpo' spread without the necessity of them.

bservations made during limited periods on of growth of the shrimp are recorded. should be undertaken to find out suitable en the natural food is exhausted.

he low rate of survival may be due to rs as well as to the difficulty encountered otal cropping of the stock. It is necessary 'sugpo' in ponds which have previously been drained and dried so as to reduce the of predation to a minimum.

roper pond layout and construction may minate the cumbersome methods of collect- transplanting the stock. Studies should made to develop appliances to facilitate ng, such as are used in shrimp capture from waters.

6. The most important factor that may limit the development of this promising industry is the uncertain and limited supply of the stocking material. A nationwide survey should be made to determine 'sugpo' fry grounds and seasons as well as the feasible methods for their capture.

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15

HRIMP EXPLORATION AND GEAR RESEARCH IN THE GULF OF MEXICO

by

H. R. Bullis, Jr.*

e is little known about the origin of the cial shrimp fishery in the United States. show that shrimp were successfully canned coast of the Gulf of Mexico as early as 1867. t known commercial shrimp fishing was done st nets and beach or haul seines. Until of the catch was taken with this gear, both he coast of the Gulf of Mexico and on the Atlantic coast of the United States. About he the otter trawl was introduced into the and rapidly gained wide acceptance, replac- ost all other gear.

fishery developed on several relatively d fishing grounds along the South Atlantic lf coasts, although the use of otter trawls new grounds in deeper waters not available rs. By the mid 1920's mechanical hoisting ent had been introduced and wire cable was g rope for trawling warps. During the nd 40's the most noticeable change was in ogressively increasing size of trawls and The various restricted fishing localities fostered the gradual development of specialized gear designs. There was relatively little liaison between fishermen and net makers from the different areas and each localized fishery used its own favourite gear. No valid comparisons could be made between the various designs.

In 1950, the consumer acceptance of two species of shrimp previously found unacceptable coupled with the discovery of new beds of these species in the Gulf of Mexico caused a sensational influx of shrimp boats from the Atlantic coast, and for the first time the popular trawls from different areas were put on a competitive basis. The Atlantic coast vessels brought in the balloon trawls and fished it in competition with the different types of flat trawls that had previously gained wide acceptance in the Gulf. Soon, fishermen who had never used anything but flat trawls were trying balloon trawls. Later, trawls embodying features of both styles were used. Some trawl makers in the north Gulf tried making balloon nets without ever having seen one, and unusual designs were produced. Gulf fishermen,

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cting Chief, Gulf Fisheries Exploration and Gear Research, Fish and Wildlife Service, U.S. Department of the Pacagoula, Mississippi, U.S.A.

not quite willing to go all the way with a new idea, were tying the wing tips of the balloon trawl up close to the trawl door instead of allowing the customary 15 to 30 feet between wing tip and door.

Thus, the gradual evolution that has taken place during the development of shrimp fishing equipment follows three general lines. First, there were vessel design changes that were needed to cope with the changing nature of the fishery. The trend was toward increased size permitting greater payloads and seaworthiness, and resulted in the growth of a large migrant fleet that was capable of travelling seasonally between widely scattered shrimping areas and fishing in deeper water. Second, there were deck gear and equipment changes and additions such as better winches, refrigeration, an expanding use of electronic navigational aids, and the wide-spread use of radio-telephones that effectively disseminated fishing information among the fleet. And, third, changes were made in the fishing gear itself, that is, the trawls and otter boards.

It would be impossible to enumerate the myriad of minor experiments that have taken place in the shrimp industry that have resulted in the gear that is being used today. Probably every shrimp fisherman at one time or another has tried minor gear modifications. During the course of shrimp explorations in the Gulf of Mexico by the U.S. Fish and Wildlife Service M/V *Oregon* an attempt is being made to analyze the relative effectiveness of different types of trawling gear now being used in the fishery. Attempts to select the best ‘ catcher ’ have been inconclusive. In the areas of very good fishing, no appreciable difference was found between a 74-foot balloon net and a 100-foot flat trawl. The balloon trawl caught more trash fish and less bottom debris such as shells and sponges, and the catch of shrimp was generally in better condition than catches taken by flat trawls.

Comparisons of the effectiveness of trawls are very difficult to make even when most of the factors of difference can be determined. For example, several comparative pairs of drags were made in the same place using a 40-foot flat trawl and a 100-foot flat trawl. The 40-foot net caught approximately two-fifths as much material in 30 minutes as did the 100-foot net but since the vessel travelled two nautical miles dragging the 40-foot trawl, and the 100-foot trawl travelled only one and one-quarter miles during the 30-minute interval, the relationship of the catch between the two net sizes could be coincidental. There is little question that each rig combination (net, doors, cable and boat) not only has an optimum working speed but is selective in regard to the catch to a considerable degree.

During the expansion of the shrimp fishing grounds the fishermen have come up against the same problem that trawlers in other fisheries have had. Slowly through experimentation many have been overcome; others have not. For many years it was known that certain areas around the Mississippi Delta held large quantities of shrimp but the soft mud bottom which quickly bogged the existing trawling gear prevented exploitation. In 1952 a device known as the mud rope was introduced from the North Atlantic trawl fishery and permitted utilization of many of these areas. The mud rope was nothing more than a cable wrapped with old fish netting and burlap to a diameter of four to six inches and tied directly to the ground line of the shrimp trawl.

One of the most vexing problems found on the Campeche and Dry Tortugas pink shrimp grounds was the vast accumulation of shell and other bottom debris that was picked up by the trawl and held in the cod ends, rapidly wearing through the netting and causing the loss of the entire catch. Within a year a ‘ shell line ’ had been evolved which practically eliminated this problem. This ‘ shell line ’ was simply a length of 3/8″ chain shackled on each end to the trawl doors, running parallel to the ground line of the trawl and attached to it at one foot intervals with 8-inch sections of light chain or manila rope premitting the ground line (on which the net was hung) to ride up off the bottom. The shell and other debris passed between the chain and the ground line and escaped being caught.

Since the opening of the Dry Tortugas grounds in 1950, exploration has been carried out along most of the west Florida coast by the U.S. Fish and Wildlife Service, the State of Florida, and a good many individual fishermen. Although no grounds rivaling those at Dry Tortugas have been located, several indications of a fishery potential were found over a wide area. This area, however, is characterized by a heavy growth of loggerhead sponges and has even to this time held exploitation to a minimum. Occasionally small pockets of shrimp have been found in heavy concentrations. The customary procedure for the boat has been to buoy off the area and spend several days literally cleaning out the sponge beds. For the most part, this approach has required more effort than was justified by the volume of shrimp caught. Some work has been carried out on the *Oregon* developing a bottomless-type trawl that rides high enough off the bottom to avoid catching the sponge while using a tickler chain between the doors to tear the sponge loose and scare the shrimp up where they can be caught by the trawl.

Very little exploration has been carried out on live coral bottom. A few successful drags have nade using excessively heavy gear (such as ad small mesh cotton netting hung on wire ith the bottom of the net protected with oullhide).

of the gear problems encountered during egon's shrimp exploration have presented unique aspects that require lengthy experi- on. In 1950 a few catches of commercially e but hitherto unmarketed species of red were made in very deep water in the northeast f Mexico. Subsequent work showed that cies was found concentrated only in depths to 275 fathoms. During this additional tory work gear damage and loss was so e that the commercial potentialities appeared nable. The bottom throughout this entire characterized by a cohesive mud that does ily wash through the meshes of the trawl, causing overloading and bogging. It was ned, through trial and error over a period of years, that one of the most critical features was the amount of trawling cable that was uring a drag. If the normal ratio of length ling wire to depth of water was employed ur invariably bogged and was lost. The of determining an optimum ratio is still experimentation since there is an apparent ange with depth. However, it appears to be e to obtain the bare minimum length which ep the trawl riding lightly on the bottom. efforts toward the solution of this problem lude the use of wire cable meters to deter- ne precise footage used, and dynamometers to the trawling wires to indicate the length it takes for a trawl to reach bottom when t wire lengths are used, as well as indicating rd the trawl doors and net are digging on tom.

mmary, the shrimp fishery in the Gulf of and the southeastern United States is still te of development, and gear changes can be d to continue indefinitely or until such a at all local utilizable stocks have been dis- and are being exploited and the attending ition problems encountered are solved.

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16

SOME ASPECTS OF PRESERVATION OF PRAWNS IN MADRAS

by
R. Venkataraman,[1] S. T. Chari[2] & A. Sreenivasan[3]

Prawns form one of the major fisheries of the West Coast of Madras, ranking sixth in order by quantity landed and by value. Large quantities of marine and estuarine prawns are also available in and around Pulicat Lake, Muthupet, Point Calimere and Pamban in the East Coast of the State. The freshwater prawn fishery of Collair Lake and Upputeru River, and the estuarine prawn fishery of Chinnagollapalem and Bantumilli in the Circars Coast also yield substantial catches of commercial importance. The importance of landings of the prawns on the West Coast can be inferred from the statistics collected by the Fisheries Department for the years 1943-50, which show an average of 200,000 maund* valued at 2½ million rupees. The catches comprise mostly *Penaeus indicus*, *P. monodon*, *Metapenaeus monoceros*, and to a lesser extent, *Penaeopsis* spp. etc.

Methods of Curing

1. *Beach drying :* This is one of the most primitive methods in vogue for preserving the large catches of prawns on the West Coast. The prawns are simply strewn on the sand and allowed to dry by solar heat without any preliminary cleaning or treatment. Although this product is still marketed for human consumption, the methods used not only make it unhygienic and insanitary, but it is also contaminated with extraneous materials and admixed with sand. During the monsoons, when drying is impossible, large quantities of this type of prawn are spoiled and are utilized as manure.

2. *Smoking :* Smoke-curing of prawns is practised on a cottage industry scale in the Circars. The prawn catches of the fisher-folk are blanched either in plain boiling water or weak brine and then spread on bamboo trays erected over a smoky smouldering fire. Preservation is achieved by the preliminary blanching, then by the loss of moisture and by the heat of the smoke and the deposition of smoke constituents. Here the prawns are in shell and hence perfect drying does not take place. The product is sold in weekly *shandies* (trade fairs) where they are purchased by wholesalers for export.

3. '*Prawn pulp*' *making :* This is one of the most universally adopted methods both on the West and the East Coasts. The prawns are boiled sea water or weak brine and sun-dried in the sh on bamboo trays or mats. After the product hard dried, it is packed in jute bags and beaten with clubs, when the shells separate out from meat 'pulp' for subsequent winnowing. In this process there is some loss as some of the flesh is removed along with the shells. The 'pulp' so obtained exported, mainly to Burma and Malaya. There a flourishing trade in this commodity in Cochin and to a lesser extent in the Circars.

4. *Semi-drying :* This is the most scientific method of preserving prawns in India, which has been initiated by the Madras Fisheries Department at its Tanur Experimental Station. Chopra (194 in his Presidential address to the 30th Indian Science Congress, commented on the progress made Tanur, on prawn processing. Manufacture of semi-dried prawns was later continued on a commercial scale in the prawn processing station Pulicat and at the Fisheries Technological Station at Kozhikode (Calicut). Chari and Pai (1946) and Venkataraman and Sreenivasan (1954) here described the process in detail. It consists of 'blanching' cleaned prawns in 4-6% brine in a tinned copper vat for 2 to 3 minutes, removing the shells by hand, followed by bringing in 25° Be brine and drying. Normally, drying was by solar heat but during inclement weather an artificial drier was also used. Infra-red drying of the prawns has also met with some success at this station. Raised bamboo thaties on scaffolds were used for drying prawns. It has been found that for every 100 pounds of raw prawns, 16 to 20 pounds of semi-dried prawns and 10 to 12 pounds of dried prawn shells are obtained. Table I below shows the chemical composition of both the fresh prawns and the dried products.

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[1] Superintendent, Fisheries Technological Station, Tuticorin, India.
[2] Assistant Director of Fisheries, Vellore, India.
[3] Fresh Water Biological Station, Bhavanisagar, Madras, India.
* (1 maund=82 2/7 lbs.)

TABLE I

Chemical composition of fresh and processed prawns (*Penaeus monodon*)

articulars	Water %	% composition on moisture free basis							Insolubles	NaCl
		Protein	Ash	Fat	Carbohydrates	P	Ca	Fe mgm%s		
n prawns	78.46	81.91	7.15	1.90	9.04	1.59	1.01	21.36	..	1.39
-dried prawns	40.60	62.59	24.33	1.65	11.43	1.05	1.05	17.82	0.40	17.18
h-dried prawns	22.65	59.91	30.17	0.93	8.99	1.66	0.54	8.68	19.86	2.43

ıtaraman *et al* (1953) have worked out the e of this process. Besides inactivating the c enzymes, blanching in weak brine reduced terial load by 98.4% and moisture by 11%. ult of brining they found the bacterial load to be reduced still further by 99.45% and moisture content by 17.3%. Table II shows the effect of blanching and brining in the semi-drying process as standardised in this laboratory.

TABLE II

Effect of blanching and brining in the semi-drying process of prawns

	Bacterial count per gm.	Reduction in Bacterial count % of fresh prawns	Total volatile bases mg per 100 gm.	Moisture %	NaCl %
awns	5,650,000	..	21.00	80.97	0.33
prawns	90,000	98.42	15.40	69.95	1.56
rawns	23,500	99.45	10.20	63.67	9.97

Composition and Nutritive Value

s I and III give the chemical composition raw prawns, semi-dried prawns and beach awns, as worked out by Chari and Pai (1946) ri (1948).

It can be seen that fresh prawns contain 78.5% of water and on a moisture-free basis, 81.9% protein, 1.59% phosphorus, 1.0% calcium and 21.36 mgm.% of iron. Except for a very slight loss of soluble proteins as a result of semi-drying, the nutritive

TABLE III

Percentage chemical composition of the various species of prawns

entific Name	H_2O	Protein	Fat	Ash	Carbohydrates	P	Ca	Fe mgm.%
nonodon	78.46	17.64	0.41	1.54	0.79	0.35	0.28	4.66
is dobsonii	78.87	18.01	0.42	1.68	1.02	0.34	0.15	9.42
emisulcatus	76.70	20.76	0.69	1.49	0.36	0.33	0.28	6.92
naeus asper	78.59	18.74	0.85	1.23	0.59	0.26	0.18	1.80

value remains intact. In the crude ' beach dried prawns ' analysed by them, insolubles alone account for 19.86%, which is no doubt largely due to admixture of sand, while the mineral content is also lowered. In Table III it is shown that *Penaeus monodon*, *P. semisulcatus* and *Penaeopsis dobsonii* have identical chemical composition but that *Trachypenaeus asper* has a slightly lower nutritive value, and in particular a rather low content of iron, calcium and phosphorus. Airan *et al* (1953) have shown by chromatography that the Bombay lobster, *Palinurus polyphagus* contained the following amino-acids : Leucines, Phenylalanine, Valine, Methionine, Tyrosine, Lysine, Histidine, Cystine, Glutamic acid, Arginine, Alanine and Proline.

Pickling

Experiments on the pickling of prawns were tried at the Tanur Experimental Station. Prawns were pickled in brine in glass jars and heat processed at 105°C under a pressure of 10 lbs. Preservation was found to be effective up to one year (Administration Reports 1928-40). But instead of fresh prawns, ' semi-dried ' prawns were used and so the product was not relished in the U.K. Later, at Madras, prawns were pickled in vinegar, oil and spices and this product was very much appreciated in the various exhibitions. Since the Indian consumers have a preference for salt-spiced products, pickled prawns are bound to have a good consumer appeal.

Other methods of preservation

Freezing of prawns (frozen shrimp or lobster tails) is a promising possibility which can be tried out when the ice plant and cold storage at Calicut is in operation. Successful experiments in freezing prawns in the shell into blocks were carried out.

Packing, storage and keeping qualities

The beach-dried prawns and prawns cured by primitive methods on the East Coast have a very short storage life. The ' semi-dried ' prawns have a maximum life of two months when stored normally in tea-chests. On the West Coast, owing to high humidity, fungal attack occurs after two months, while on the East Coast this is less frequent, ' salt excrescene ' being more commonly met with.

Various types of paper and indigenous substances were tried as packing materials, e.g. newspaper, brown cartridge paper, butter paper, dried lotus leaves, dried plantain leaves, paper treated with benzoic acid, boric acid etc., cardboard cartons, bamboo woven baskets etc.

It was found that one of the cheapest and most efficient combinations was the bamboo basket lined with butter paper. These were found to be quite convenient for storage and transport by rail or bus, added very little weight to the product, could be used over again, and because of flexibility were the least damaged in transit. Clean kerosene tins have also been used for transport, but these are liable to rust.

Laboratory scale experiments were carried out with semi-dried freshwater prawns stored in sealed tins in an atmosphere of carbon dioxide. This system maintained the product in fresh condition for eight months, both the colour and flavour remaining unaltered and the prawns in prime condition. Large scale preservation of prawns in CO_2 gas was also carried out at Tanur Experimental Station and later at Akividu. Semi-dried prawns were kept in anaerobic jars into which CO_2 was passed and observations were made periodically in this laboratory in 1952. Because of the transparency of the container, observations could be made without opening the container.

Evidence was available that for the 6½ months that observations were continued, the semi-dried prawns retained their pink colour and good condition, while the control prawns were spoiled, becoming sticky and black in two months, with production of ammoniacal off-odours. No fungal growth was noticed. The bacteriological quality of the CO_2 preserved product was satisfactory, the original bacterial content of 7900 per gm having risen after 6½ months storage, under CO_2 gas, to only 9600 per gm.

For retailing, butter paper and cellophane packets were being used in this Station, but these have now been superseded by ' Alkathene ' bags (Venkataraman and Vasavan 1953), a polyethylene plastic of Imperial Chemical Industries. Storage in Alkathene bags was found to be very convenient, since they had an eye appeal, prevented excess loss of moisture and were vapour and vermin proof. This method is now being used for large scale transportation and half pound and one pound packets are made in Alkathene, which are heat sealed and packed in plywood chests for transportation over long distances to such places as Calcutta, Shillong and Darjeeling where they have arrived in good condition.

Chemical preservation

Incorporation of various harmless chemicals in the brine for preserving semi-dried prawns over longer periods was tried at this Station. Benzoic acid, salicylic acid, sodium nitrite, acetic acid, boric acid and hexamine were used. Preliminary experiments have shown that sodium nitrite, hexamine and 0.1% acetic acid can extend the shelf life of semi-dried prawns. Further work on these lines is however desirable. The addition of ascorbic acid was found to encourage fungal growth (Venkataraman rs, *loc. cit.*), though it reduced the bacterial e effectively.

By-products

rawns consist mainly of the chitinous shell muscle (meat), the two together forming % of the weight. The hepatopancreas as the 'berries' or eggs of the freshwater aids are also often eaten. The meat and h constitute nearly half the wet weight of When prawns are shelled for semi-drying, s are not discarded but are dried, powdered, nd converted to meal which is found to about 41.0% of protein and fairly high of calcium (13.2%) as CaO and phosphorus s P_2O_5) and it has therefore been recom- as poultry feed (Chari and Pai 1948). When ith shark meal or any lean, high protein l, it can be used as cattle fodder and is useful for fattening pigs; in fact, all y institutes in Madras State now use fish feeding cattle. Since the chitinous shell a polymer of acetyl glucosamine, experi- e under way to see if this chemical, much ntravenous preparations, could be prepared ally from shells.

Microbiology

acterial flora of fresh prawns has not been here. Venkataraman and Sreenivasan shed 1951) noted that the semi-dried prawns ra of predominantly aerobic spore-forming and *Micrococcus* and this agrees with their hat salted products invariably retain these id., 1954).

Utilization

dried prawns can be utilized in almost the nner as fresh prawns. After a preliminary g in warm water, they could be deep-fried ith condiments, used in gravies and sauces, into pastes or cutlets. The shells also are o pastes by poorer people.

ods of capture and transportation of prawns

West Coast of India, especially in Cochin, re caught in the backwaters by the use of dip nets, using powerful lights to attract vns. In the sea, shoals of prawns are in a sort of bag net, the '*Paithu vala*'. etailed account of the craft and tackle of the West Coasts is given by James Hornell (1927 and 1941). Stake nets are used to catch migratory prawns in the West Coast rivers.

On the East Coast the following types of nets are used for capturing prawns in the sea and backwaters. The *Eru valai* is a conical bag net of small mesh especially for the capture of prawns. The *Konda valai*, also meant specifically for prawns, is a sort of upright stake net fixed in a helicoidal fashion. A somewhat similar type of stakes net, the *Kattu valai*, is also used in backwaters. The *Kuzhi valai* is a type of drag net used seine fashion, with the unusual characteristic of having the mouth crossed and distended by wooden rods. Prawns are also caught along with other fishes in the *Thuri valai*, a primitive trawl (like the Italian trawl). The catches of this net are poor in keeping quality, due to the heavy pressure of the fish caught along with the prawns. The *Siru valai* and *Kal valai* are two small bag nets used for catching prawns in backwaters.

In the rivers, migratory prawns are caught in stake nets, which differ from those described above as used in backwaters. There is a profitable stake net fishery in the Upputeru river, where the nets are 105 to 120 feet long. These are tied to permanently fixed posts, 10 feet apart, the mouth of the net being distended by ropes and the head ropes tied near the surface. Slip knots are tied for the foot ropes, which are pushed down with a long pole, or by a person operating it with his foot and dragging it down. The open cod end is closed with a trap funnel made of bamboo. In the swamps of Collair and Upputeru river, basket traps are extensively used in batteries for the capture of prawns. One type, called *Gampa garre* is a telescopic two-piece bamboo funnel-like device; the other, the *Mayulu*, is a rectangular bamboo basket cage or trap. The prawns caught in traps are always better in quality as compared with those caught in nets.

The normal mode of transport from the catching place to the market or Railway Station is on foot by means of a long shoulder pole on either end of which is slung a basket, the prawns being covered with fresh green leaves or with aquatic weeds to keep them cool. In inland areas, a distance of up to about 8 to 12 miles is covered in this fashion in 3 to 4 hours. Prawns are sent to Madras from the backwaters of Pulicat, partly by country boats (16 miles in 6 to 8 hours) and partly by cart or bus (12 miles in 1 to 3 hours). They are not iced and more often than not they are not in prime condition. However, the State Government now has a van for the quick transport of these prawns in iced condition. About 60% of the catch is consumed fresh.

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17

MARKETING AND UTILIZATION OF SHRIMP IN THE UNITED STATES

by

D. M. Clifford*

In 1954 the catch of shrimp in the United States was 265 million pounds. Shrimp used for canning amounted to 54 million pounds, or 22 per cent of the catch. The remaining 78 percent was marketed almost entirely as fresh and frozen shrimp (See tables 1 and 2). Over 95 percent of the shrimp produced in the United States is landed in the South Atlantic and Gulf States, which include North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. The balance of shrimp caught by United States fishermen is taken along the Pacific Coast, in California and Alaska. The shrimp fishery is currently the most valuable fishery in the United States at the fisherman's level.

There are three principal varieties of shrimp: (1) white (*Penaeus setiferus*), (2) brown (*Penaeus aztecus*), and (3) pink (*Penaeus duorarum*).

Commercial quantities of a fourth species, a deep-water red shrimp (*Hymenopenaeus robustus*) were discovered by the United States Fish and Wildlife Service's exploratory vessel *Oregon* in lat 1950. However, this species is not being fishe commercially due to the current abundance of othe varieties and the deep waters in which red shrim are found. They are caught in depths of 200 t 275 fathoms, which require special deep-wate trawl gear, used mostly experimentally so far. A the gear is improved and the demand increases it i expected that red shrimp will be fished and eventuall appear on the market. However, from informatio now available, it is believed that the quantity lande will not be as great as other varieties. The fac that catches may be limited would place red shrim in a specialty category. Recalling earlier consume educational efforts required to establish brown shrimp on the market it can be expected that there will be somewhat similar problems connected with marketing red shrimp. It should be noted, however, that those persons who have had the good fortune to sample red shrimp believe they are superior in appearance and flavor.

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* Commodity Industry Economist, U.S. Fish and Wildlife Service

TABLE I

Supply and Disposition of Shrimp 1950-1953 Round weight—Heads on

Item	1950	1951	1952[1]	1953[1]
	Pounds	*Pounds*	*Pounds*	*Pounds*
ply :				
tch (Round weight)	191,474,000	224,316,000	227,221,000	235,000,000
ports (Round weight basis)	67,533,000	70,262,000	64,629,000	72,397,000
Total	259,007,000	294,578,000	291,850,000	307,397,000
osition :				
nned	41,918,000	44,955,000	46,730,000	58,620,000
ried	8,000,000	8,000,000	8,000,000	8,000,000
ozen	156,000,000	168,700,000	157,037,000	167,651,000
esh	53,089,000	72,923,000	80,083,000	73,126,000

[1] Preliminary
Source: U.S. Department of the Interior, Fish and Wildlife Service

TABLE II

Supply of Shrimp, Various Years (In thousands of pounds)

Year	United States Catch			Imports		Total
	Heads on	Heads off	Percent of total	Heads off	Percent of total	Heads off
	Quantity	*Quantity*	*Percent*	*Quantity*	*Percent*	*Quantity*
1939	150,250	89,399	96	3,984	4	93,383
1948	167,000	99,365	82	21,563	18	120,928
1949	175,000	104,125	78	29,673	22	133,798
1950	191,474	113,900	74	40,198	26	154,098
1951	224,316	133,521	76	41,824	24	175,345
1952	227,221	135,250	78	38,471	22	173,721
1953[1]	257,000	152,976	78	*43,094	22	196,070
1954[1]	*265,000	157,738	79	41,542	21	*199,280

* Record
Source : U.S. Department of the Interior, Fish and Wildlife Service

Marketing Shrimp Ex-vessel

ere are two principal classes of shrimp fishing ls : (1) the small boats, 30 to 45 feet in length, fish primarily in inshore waters, and (2) the vessels, 50 to 75 feet in length, that fish almost ely in off-shore waters.

nancial agreements regarding compensation the sale of shrimp between the fishermen, owners and dealers follow no set pattern and with location and customs of the trade in the where transactions take place. Generally, ments are on a share basis with proceeds allo- between (1) the captain and the crew and (2) the boat owner. An example of the sharing agreement commonly used is a 60/40 percentage basis. Of the 60 percent, 20 percent goes to the captain and 40 percent goes to the crew. The remaining 40 percent goes to the boat.

Each party to the agreement is entitled to compensation determined by the particular financial arrangement affecting each boat. If the boat is owned by the buyer of the shrimp, he is entitled to the boat's share and the captain and crew share the balance. If the captain is the owner, he is entitled to the boat's share plus the captain's portion of the crew's share. Shares are determined sometimes before and sometimes after deduction for such items as ice, fuel, oil, and food. In some cases, ice may be provided by the buyer of the catch. In parts of Louisiana, for example, vessel license, fuel and one-half of the ice are furnished by the vessel owner.

Prices paid to fishermen are established in several ways. These prices are referred to as ex-vessel prices. In many instances, prices are prearranged between the boats and the buyers before the boats leave port. At one time, fishermen's unions or associations in some states set the minimum price acceptable for shrimp landed. Frequently, when boats are leaving for shrimp fishing, buyers will make it known that they will pay a certain price for shrimp, without a formal agreement with the fishermen. Under this arrangement, upon their return to port, fishermen sell their catches to the buyers who are willing to pay the highest price. In other words, even though no agreement exists between buyer and fishermen, they have a fair idea of what price to expect for their catches.

It is difficult to indicate ex-vessel prices in a general statement since they are established by local agreements. For example, prices at Port A are quoted low as compared to Port B since the buyer at Port A pays for the vessel license, fuel and similar items.

About one-half of the shrimp are landed as they are caught, i.e., with their heads on, and the other half are headed and, in a few cases, frozen. Shrimp is sold almost exclusively according to size, which is determined by the number of shrimp in a pound. The number of shrimp in a pound is generally spoken of as the "count". Counts begin at 15 and under, increasing in multiples of 5 up to 26 to 30, and thereafter in multiples of 10 through 60 and over. Shrimp sold ex-vessel are measured by the barrel or box, according to count per pound, which is generally determined by sampling. The count for large size shrimp is determined by counting the number of shrimp in several five-pound samples. A one to three pound sampling measure is generally used for smaller sizes. The larger the shrimp, or the lower the count per pound, the higher the price.

Generally, prices are quoted at ports, either by the box or barrel exclusively. For example, Florida and Texas landings are mostly in 100 pound boxes, whereas Mississippi, Alabama and Louisiana measure their landings by 210 pound barrels. Shrimp measured by the box are usually headless, while those measured by the barrel are not.

There are variations in methods of landing shrimp. In some parts of Louisiana, Mississippi and Alabama, freight boats gather catches of the in-shore fleet and land them as a single load. This enables inshore boats to remain longer on the fishing grounds, which may be miles from their home port. Freight boats also fish while on the shrimp grounds, before they return to port. A small fee is charged by the freight boats per barrel landed of the catches from the inshore vessels.

Large shrimp trawlers that fish off Campeche, Mexico, and land their catches on the West Coast of Florida follow the practice of having a single vessel return to port with the catch from several vessels. Each boat prepares its shrimp heads-off in 100 pound boxes and the separate landings are credited to the respective accounts. No fee is charged for the service of the returning boat, since each boat is expected to reciprocate.

Marketing Fresh and Frozen Shrimp

Two principal types of shore plants purchase shrimp from the boats: (1) raw shrimp houses and (2) canneries. Some raw shrimp houses also process and freeze shrimp. It is not unusual to find a shrimp dealer who purchases shrimp ex-vessel and performs several functions, such as packing and shipping raw shrimp, and breading, cooking, canning, or freezing shrimp. Raw shrimp plants are generally equipped to head, wash and ice shrimp in 100 pound wooden boxes. These are shipped fresh to various Eastern markets, breading and cooking plants, and to some freezers.

Most shrimp landed in Texas is frozen before shipment to distant markets. Fresh shrimp is shipped from the States of Louisiana, Mississippi, Alabama, Florida, Georgia, North and South Carolina, and is almost always destined for New York or one of the large cities situated on or near the truck routes from the point of origin. Chicago no longer has a fresh shrimp market and all of the shrimp now shipped to Chicago is frozen.

Generally the Chicago wholesale market deals in larger size shrimp, mostly from Texas and Louisiana. Frozen shrimp arrivals at the Chicago market were 17,347,000 pounds in 1954, with 16,676,000 pounds or 97 percent arriving via refrigerated truck as contrasted to only 671,000 pounds or 3 percent via railway freight.

In contrast to the Chicago market, the New York market sells a great deal of fresh shrimp in addition to frozen. Ninety-one percent of the fresh shrimp originates in the South Atlantic States of Florida, Georgia, North and South Carolina. Shrimp arrivals at the New York market in 1954 were 20,722,000 pounds of which 13,204,000 pounds or 64 percent were fresh shrimp and 7,518,000 pounds or 36 percent were frozen. All of the fresh shrimp

88 percent of the frozen shrimp were transported efrigerated trucks.

holesale shrimp prices are quoted daily by the ed States Fish and Wildlife Service through its ket News Offices at Chicago and New York.

Price ranges are quoted rather than single prices, since quality and supply have a direct bearing on prices within limits. The following tables shows shrimp prices quoted on June 1 at Chicago and at New York on June 13, 1955.

Wholesale Shrimp Prices

	Frozen at Chicago June, 1, 1955		Fresh at New York City June, 13, 1955	
	White	Brown Grooved	White	Pink Grooved
t per pound	lb.	lb.	lb.	lb.
15 & Under	79	77-79	None	None
15-20	76-78	73-75	75	75-78
21-25	71-73	68-70	75	72-73
26-30	None	63-65	68-70	68-70
31-40	None	None	63	63-65
41-50	None	None	53-55	50-52

resh shrimp shipments, via refrigerated truck astern cities, are usually made on a commission s or on direct sale to a buyer. The most desirable ngement is where shrimp is sold previous to ment or while en route to the market. Fre- ntly, for example, a shipment en route to New k will be sold in Philadelphia by the owner or agent. Truckers are sometimes instructed to at a telegraph office in a designated city for delivery orders, as a safeguard against changes riginal plans while the shipment is en route.

lling fresh shrimp on a commission basis involves ich greater risk for the producer than shipment hrimp at an agreed price. If the arrival time nsold shrimp or commission shrimp occurs when market is over-supplied, the owner may either to sell at a low price or elect to freeze the unsold np and sell later, when the market is more rable. However, this involves freezing and ge costs and the tying up of capital, all of which sked on the premise that a better price can be ined at a later date. The quality of the shrimp en, under the circumstances described above, t also be considered as part of this risk, since quality of fresh shrimp becomes poorer with

ozen shrimp is sold by market dealers through same methods as fresh shrimp, although larger ntities of frozen shrimp are handled by wholesale brokers than are sold directly by dealers or on mission.

n the wholesale market, fresh and frozen shrimp sold by count, with the larger sizes bringing higher prices. There is also a price differential between the different varieties of shrimp, with white shrimp bringing higher prices than brown or pink shrimp of comparable qualities. Under normal market conditions, when supply and demand are in equilibrium, there is a price differential of about 5 cents per pound between the various counts. Wholesale market counts generally used are in multiples of 5, up to 26 to 30, and in multiples of 10 after 31.

In actual practice, the number of shrimp in a shipment designated 21 to 25 or 26 to 30 do not all fall within the given range, but will average close to it. Shipments in this category are useful to processors who do not require specific grading, such as breading and cooking plants and packers who freeze for consumer use. However, institutions like large hotels, restaurants and drive-in restaurants demand shrimp counts in a close range. Some of these institutions will purchase only 26-30 count shrimp, knowing that 5 to 6 shrimp will be equivalent to one serving, thus eliminating additional measurement. Wholesale fish brokers or shrimp dealers unable to guarantee close grading of large shrimp, find it difficult to sell to institutions requiring such grading. A good percentage of the processors that handle sizable quantities of shrimp use mechanical shrimp grading machines. This type machine will do the work of 12 to 15 hand sorters. Grading machines are very efficient and are designed to handle all counts from the highest down to 15 and under.

Large grocery store or restaurant chains in some cases by-pass wholesale food brokers and negotiate directly with shrimp producers or dealers. The volume of business handled by these chains warrants their buying in large quantities.

Canned Shrimp Marketing Methods

Principal shrimp canning centers are located in Alabama, Mississippi and Louisiana, where 90 percent of all canned shrimp is produced. During 1954 shrimp were canned in 3 plants in Alabama; 16 in Mississippi; 21 in Louisiana; and one plant each in North and South Carolina and Georgia. The combined production amounted to over 934,000 standard cases, valued at over $13,691,000 to the packers.

Shrimp used for canning is usually the small or mixed grades. Canneries buy all grades of shrimp, but can generally sell the lower counts of shrimp fresh or frozen for a better price than they would bring as canned. However, some low count shrimp is canned, particularly when the market is liberally supplied and prices are low. Most small shrimp is landed by inshore boats, although the amount being bought by canners from off-shore vessels is increasing.

Nearly all canned shrimp is brine packed, commonly called "wet pack". Most of the 'wet pack' shrimp is put up in 5 ounce cans, although 4½ ounce cans are becoming more popular. Cans are packed predominantly in cartons of 48 and 24. In many instances, canned shrimp is sold to large grocery chains or wholesale dealers who have their own brand label.

Canned shrimp is marketed mainly by wholesale food brokers similarly to other canned commodities but some is sold directly by canners. Canned shrimp is sold in retail grocery and speciality stores in most of the large cities in the United States.

Marketing of Sun Dried Shrimp

Sun dried shrimp production is limited almost exclusively to Louisiana, with small amounts being produced in California. Over 800,000 pounds of dried shrimp were produced in Louisiana in 1954, with an estimated value of over $500,000 to the producer. Of the total production in the United States, about half was exported to Cuba, Peru and other countries.

Tiny brown grooved and white shrimp and sea bobs (Xiphopenaeus)—60 to 70 count per pound—are used for drying in Louisiana. These small shrimp and sea bobs are usually too small to be suitable for canning. After drying, shrimp are packed in 50 pound boxes and 200 pound barrels for the wholesale trade. The most common wholesale package is the 50 pound box, although smaller packages are available for local retail trade. Dried shrimp are packed for the export trade in containers the same as for the domestic wholesale trade.

Dried shrimp is marketed in San Francisco, New York and other cities having a large population of Oriental descent. Actual sales transactions are handled by speciality wholesale brokers under usual brokerage arrangements.

Dried shrimp are retailed in a bulk form, usually in speciality stores located in the Oriental sections of large cities. About 400 dried shrimp are equivalent to one pound. A quarter of a pound is considered an average sale. In the Gulf of Mexico States, near the point of production, dried shrimp are sold like potato chips in small cellophane bags.

A by-product of the shrimp drying process is "shrimp bran", which consists of the dried waste material containing shells, heads, and legs. When poultry and stock feeds are in short supply, "shrimp bran" has considerable demand. However, when other feed supplements, such as menhaden meal, are plentiful, "shrimp bran" has a very limited market and is usually sold locally as a feed mix or for fertilizer.

Varieties of Processed Shrimp

Shrimp are distributed in the United States by 1,500 wholesale firms and 170,000 retail stores. These distribution outlets offer a number of different kinds and styles of shrimp for consumers.

Fresh shrimp is marketed in fresh fish markets or grocery stores having fresh fish departments and is generally sold loose by the pound. In many cases these retail outlets will buy frozen raw shrimp in institutional 5-pound cartons, thaw it and sell it in smaller lots. Frozen raw shrimp is purchased in 8 ounce, 10 ounce, 12 ounce, 1-pound and 5-pound cartons. Sizes from 1 pound and under are classified as consumer packages. Five pound packages are usually sold to restaurants, hotels and large institutions, hence the name institutional package.

Grocery store chains usually have available several varieties of frozen shrimp in consumer size cartons in their frozen food cabinets. A description of the contents is printed on the outside of the package, usually stating whether the shrimp are cooked, raw, breaded or peeled and deveined. Breaded shrimp are of two principal types: regular, peeled, breaded shrimp and fantail breaded shrimp. Fantail shrimp are peeled, except for the last segment and tail, split, breaded and frozen. Breaded shrimp are packaged in 10 ounce, 12 ounce, 2½ pound and 4 pound cartons, with the latter two sizes being primarily for institutional use. The greater part of breaded shrimp zen raw, although a limited quantity is pre- d for use in establishments that serve “ French shrimp.” A third style of frozen shrimp is oked, peeled and deveined. It is packaged in ce, 10 ounce, 12 ounce, 2 pound, 3 pound, and nd cartons, with the 3 and 5 pound cartons institutional packages.

o relatively new products to the United States t are frozen shrimp creole and shrimp soup. n shrimp creole is packaged in 8 ounce and 2 l aluminium pans. Both the 8 ounce size which onvenient individual serving and the 2 pound vhich is family size, need merely to be heated serving. Frozen shrimp soup is prepared by l of the nation's largest soup producers and et with exceptionally good public demand. It rketed in 10 ounce metal cans, with each one g about two persons. This style soup utilizes mall and tiny grades of shrimp, which has ed in an exceptionally good demand for these

trend in food products in the United States vard high quality, and simplicity and ease of ration. There is a large potential market for table food items that can fulfil these require- . Frozen shrimp creole and shrimp soup meet standards and consequently have a bright . Breaded shrimp of both the fantail and r style have been marketed in the United for several years and have well established ts. Their marketing future, however, is dent upon market promotion, quality control, mpetition from new products. As an example, f breaded shrimp declined sharply upon the uction of fish sticks. That loss now seems to rcome as the novelty of fish sticks begins to . Fresh and frozen raw shrimp have an estab- market which undoubtedly will be maintained future.

mp aspic, bisque, cakes, cocktail curry, gumbo, rg, paste, and smoked shrimp are speciality which are not produced in volume comparable frozen and fresh items. Dried shrimp has a l market, restricted primarily to cities having tion of Oriental descent. Canned shrimp compete with canned fish and meat, conse- y expansion of its market depends upon price, and sales promotion.

United States shrimp industry has excep- y good possibilities with some markets that ot been pioneered. However, as with any food product offered to the consumer, high must be maintained and sales promotion is l to establish and retain markets.

Under the provisions of the Saltonstall-Kennedy Act which became law in 1954, research is being initiated with the objective of improving sales and distribution of shrimp products through wholesale and retail marketing channels. Most of this work is being performed by private research institutions under contract to the United States Fish and Wildlife Service.

In addition to these new studies, research is also being conducted with Saltonstall-Kennedy funds on cost studies of shrimp-vessel and shrimp packing-plant operations, shrimp vessel efficiency, work practices on shrimp vessels and operating efficiency in shrimp processing plants, and the problems of primary shrimp marketing and ex-vessel sales. The objectives of these studies are : to reduce operating costs of vessels and plants through technical advances ; to increase consumption through improved distribution, product quality, and merchandizing ; and to effect an output that will assure maximum total income.

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18

FLUCTUATIONS IN AUSTRALIAN PRAWN CATCH

by

J. M. Thomson*

These observations on the variation of the catch of prawns in eastern Australian waters are given in the belief that they will aid those members of the Indo-Pacific Fisheries Council whose prawning industries are in their infancy to understand the types of fluctuation which may occur in such a fishery. If appropriate management measures are to be taken the reasons for such fluctuations must be understood.

Pertinent Biological Factors

(*a*) *The Species.*—The principal species taken on the east coast of Australia and their colloquial names are :—

School prawn *Metapenaeus macleayi* Haswell.
Greasy-back prawn *Metapenaeus mastersi* Haswell (this is the prawn which has been referred to as *Metapenaeus monoceros* in Australian literature and may be only a subspecies of the latter).
King prawn *Penaeus plebejus* Hess.
Tiger prawn *Penaeus esculentus* Haswell.
Banana prawn *Penaeus merguiensis* de Man.

Other species which are not yet exploited to any extent are known from both New South Wales (Racek, 1955) and Queensland (Dall, 1957.). Haysom (1953) has given an easy key to the differentiation of the five main species.

(*b*) *Distribution.*—The ranges of all five species overlap, but the Banana prawn is dominant in northern Queensland, though rare south of Moreton Bay. Its place is taken to the south by the School prawn whose range extends from southern New South Wales to the Mary River, Queensland. The other three species overlap these ranges, though none of them is common north of Mary River (Fig. 1).

(*c*) *Breeding.*—The summer and autumn seem to be the normal breeding periods for the estuarine prawns. The King prawn spawns at sea from January to June but mainly in March and April (Dakin, 1938). The estuarine breeding Greasy-back spawns from November to March and what little evidence there is suggests a summer spawning at sea for the other prawns (Morris and Bennett, 1952 ; Dakin, 1938, 1940).

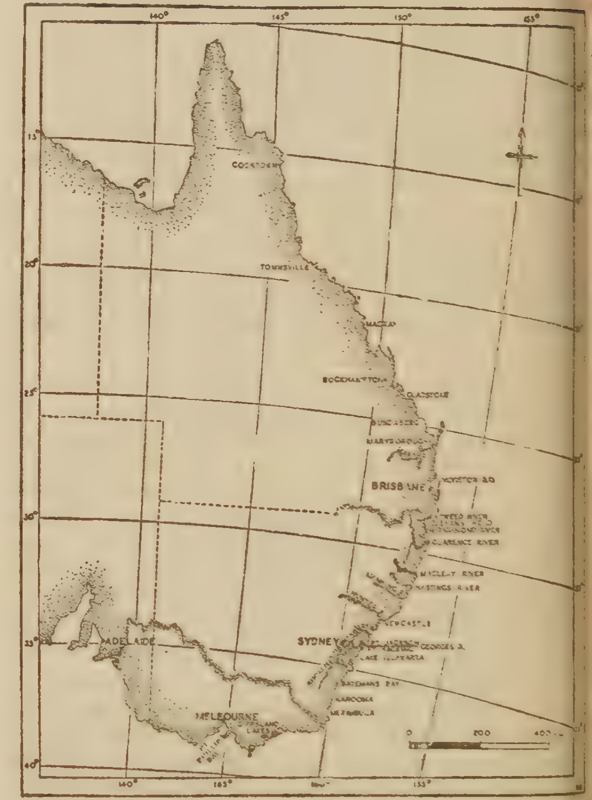
140°
145°
150°
COOKTOWN
TOWNSVILLE
MACKAY
ROCKHAMPTON
GLADSTONE
BUNDABERG
MARYBOROUGH
BRISBANE
MORETON BD
TWEED RIVER
RICHMOND RIVER
CLARENCE RIVER
MACLEAY RIVER
HASTINGS RIVER
NEWCASTLE
SYDNEY
GEORGES R.
LAKE ILLAWARRA
BATEMANS BAY
NAROOMA
MERIMBULA
ADELAIDE
MELBOURNE
GIPPSLAND LAKES
0
200
400
153°

Fig. 1. Eastern Australia showing places mentioned in the text

The Fishery

(*a*) *The Stock.*—The five species which have become important in the fishery are all forms which enter estuaries during part of their life cycle. To what extent this is obligatory is unknown. The Tiger and Banana prawns would seem less dependent upon and certainly less regular in occurrence in the estuaries than the other species. In Queensland north of the Mary River the Banana prawn is the dominant estuarine form but it does not penetrate as far upstream as the other species do (Dall 1957).

In Southern Queensland the Greasy-back is the most abundant form. The King and Banana prawns are also common in the summer catches and the Tiger prawn predominates in winter. Occasional concentrations of the School prawn are taken off on Bay, but this seems to be north of this ' centre of greatest abundance.

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* Division of Fisheries, C.S.I.R.O., Cronulla, NSW, Commonwealth of Australia

prawn most commonly taken in the estuaries w South Wales is the School prawn. The prawn is also abundant and the Greasy-back ain localities. The Tiger prawn is sporadic in ence. There is some evidence that the Tiger was more abundant 60 years ago (Dakin, 1938).

Historical.—It is probable that some prawning enced soon after the settlement of New South . Certainly it was established in Port Jackson 1880 (Fisheries Enquiry Commission, But there is little mention of prawning ies even in such nearby waters as Lake Illawarra 1894 (Comm. Fish. N.S.W. 1895). The y in each of the estuaries or coastal lakes of South Wales grew up independently as trans-and distribution facilities became available. spite earlier ports of large prawns taken at sea ell, 1898 ; Schmitt, 1926), the fishery remained uarine one until 1948 when, as a result of re-endations by the C.S.I.R.O. Division of ries in 1946 a prawning ground was located at ton near Newcastle. Prawns have now been from some 31 beds at sea, but only five or six of importance. Similarly, although prawns narketed from 56 estuaries and coastal lakes the New South Wales coast only six or seven ice them in large numbers.

e fishery in Queensland developed in much the same way, but the seaward expansion came a little later stimulated by the discoveries in New South Wales. Exploration is proceeding northwards and during the summer of 1955 extensive new beds were worked near Mackay.

(*c*) *Gear.*—The earliest gears used in the estuarine prawn fishery were small meshed sunken seine nets, and subsequently set pocket nets, scoop nets, and otter trawls have been used. A special sort of set net known as a striped net is used in some Queensland waters, notably in the Mary River.

(*d*) *Management.*—There are restrictions on the size of gear and the mesh of nets (see New South Wales Fisheries and Oyster Farms Act, 1935-49, Regulations and Queensland Fisheries Act Regulations). These are applied individually to the case of each river so that nets of different specification are used in various places according to local peculiarities of topography and of the stocks. Minimum sizes are prescribed and in the estuaries the fishermen are required either to riddle their nets (Queensland) or to place the prawns in meshed boxes known as swimmers (New South Wales) to allow the small prawns to escape. A blubber trap to keep jellyfish from the bag of the net is necessary in otter trawls.

(*e*) *Seasonal Catch.*—In all waters the greatest catches are taken over the summer period from October to April (Table I), i.e. during the period when the prawns are schooled up prior to spawning.

Table I

Monthly catches in pounds

5-*year average* (1948-49 *to* 1952-53)

District	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
l ..	890	806	952	1,335	**2,298**	398	504	600	963	4,470	**4,999**	3,101
a ..	51,139	39,964	1,01,912	**1,18,731**	61,335	62,308	5,958	33,567	60,906	72,135	6,2908	,47592
an ..	14,567	16,980	10,185	**20,577**	7,927	12,385	1,064	3,694	7,719	18,878	15,441	14,949
ucca ..		43	499		258				1	56	20	209
acquarie ..	**20,753**	1,854	5,521	7,955	7,567	10,038	37	1,019	5,968	9,882	15,010	11,196
..	4,439	11,264	5,262	2,951	1,509	168	53	24	740	**16,454**	12,972	4,413
er ..	10,011	7,154	4,850	3,782	877	22	630	310	5,933	**36,195**	20,570	17,530
ephens ..	24,227	27,187	**36,268**	26,467	10,787	2,684	676	204	5,298	4,758	24,270	20,162
astle ..	55,483	56,031	**65,099**	57,776	44,110	22,479	31,133	22,303	25,520	22,066	45,107	45,646
sea ..	3,066	**4,553**	1,961	1,828	1,955	1,096	2,079	1,537	1,390	527	339	2,378
rah Lks. ..	22,219	16,298	16,304	13,314	3,734	572	201	373	4,109	26,831	**48,356**	38,136
Woy ..	**4,364**	3,974	2,977	2,403	1,888	1,056	841	769	562	1,255	2,339	3,307
esbury ..	31,466	20,427	21,027	17,134	13,833	4,338	1,193	3,295	6,865	14,998	25,194	**42,120**
ckson ..	**61,855**	45,852	38,129	16,076	8,282	4,642	1,897	2,404	5,011	16,974	37,884	51,075
e's R ..	6,595	5,473	2,198	965	1,060	547	701	491	998	4,424	**7,309**	7,182
Hacking ..	28		128									
, Illawarra ..	25,396	29,621	**30,516**	13,551	3,719	712	374	261	130	4,791	22,017	**30,810**
well Point ..	10,601	7,423	3,458	5,228	12,854	1,986	1,520	1,210	881	3,051	7,934	834
han's Bay ..	**4,178**	**5,561**	3,090	2,711	**4,603**	1,653	781	1,187	1,381	1,381	2,429	3,716
oma ..	9,788	7,802	1,171	82	90	31	0	24	0	151	630	2,825
nbula* ..	1,057	474	519	371	101	2	0	0	0	0	378	633

ears' average only

ures in black-face type indicate the months in which the greatest catches were made.

(*f*) *Annual Catch.*—Three phases of development are evident in the catch figures for New South Wales (Fig. 2). Firstly there is the early expansion phase (which, however, has its fluctuating stabilized period, as only some of the estuaries were being exploited) during which the catch was never greater than 700,000 lb. Secondly, from 1924 to 1948, the catch fluctuated between 800,000 and 1,750,000 lb. (except for a low catch of 580,000 lb. in 1933 which is probably an unreal figure as much unacknowledged fishing went on in this depression year). The estuarine catch continued to fluctuate within these limits subsequent to 1948, but the total catch rose owing to the discovery of the offshore beds.

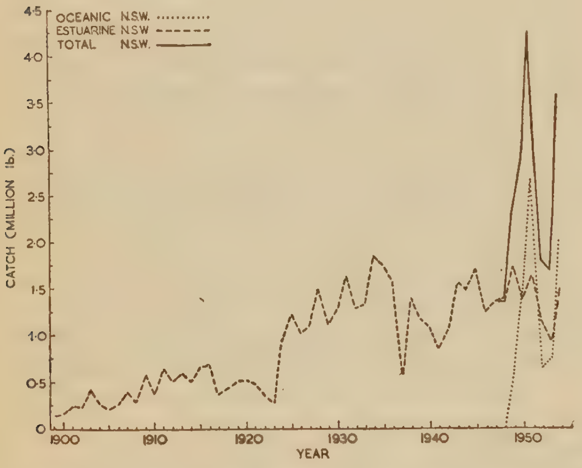


Fig. 2 Annual Prawn Catch—New South Wales.

Considerable fluctuations in catch have taken place on the prawning grounds even during the so-called stabilized period. These fluctuations appear to be correlated with rainfall (Table II).

Lake Illawarra has been selected as a typical prawning area. The correlation between rainfall and catch has been made only between the years 1924 and 1941 as prior to 1924 the fishery was only developing and after 1941 the war time drain on manpower became effective. Soon after the war legislation was enacted in New South Wales to restrict fishing activity to full-time fishermen and this had a severe effect on the Lake Illawarra commercial fishery which had been highly dependent upon part-time fishermen. The real catch probably remains large as amateurs are permitted to take prawns for their own family consumption as long as they are not offered for sale.

It will be seen from Table 1 that there is no correlation of catch with the current year's rainfall, nor with the mid-summer rainfall at the beginning of the season (November-March). The previous year's rainfall and the rainfall of two years previously show a high correlation, but the best is the correlation between the catch and the rainfall for the twelve months lasting from 18 months to six months before the commencement of the current season.

There remains the possibility that the relationship between catch and rainfall is not linear but curvilinear, in which case the coefficient of correlation (r) would not be as appropriate as the index of correlation (p). However, the departure from linearity is slight because, for instance, in the case of the correlation of catch with the combined rainfall of the previous two years, (r) is 0.76 and (p) is 0.80.

Table II

Correlation of prawn catch with rainfall—Lake Illawarra
1924-1941

(Level of significance 5% 0.482 : 1% 0.605)

Rainfall period	Coefficient of correlation
November to March (current summer) ..	0.33
Same year	0.09
Previous year	0.70
Two years earlier	0.76
Previous 18 months	0.33
18 months to 6 months before ..	0.86
17 months to 7 months before ..	0.67
16 months to 6 months before ..	0.72

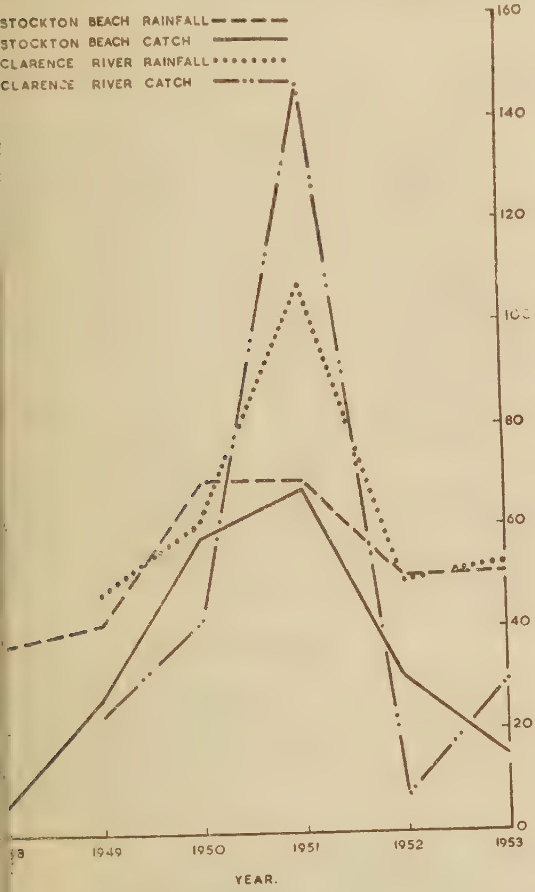
The sea beds have not been exploited long enough to give adequate data for statistical study but already large fluctuations are apparent. Graphing the catch with the previous year's rainfall (Fig. 3) shows good evidence of a similar correlation with rainfall.

Gunter and Hilderbrand (1954) also concluded that the catch of the white shrimp (*Penaeus setiferus*) along the Texas coast depended upon the rainfall on the adjoining land-mass. Such dependence may prove to be general for estuarine-penetrating penaeids.

Conclusions

The observations recorded here have significance for any country initiating or expanding its prawn fishery. Prawns are to be found not only in the estuaries but also at sea mainly on blue mud bottoms adjacent to the river mouths where the prawns are of larger size than those in the rivers and are massed in large schools.

It may be anticipated that the annual prawn catch will fluctuate widely both in the estuaries and on the eds. The greater the rainfall of the previous ears the greater the prawn catch is likely to be.



ig. 3. Comparison of annual catch and annual rainfall, Evans Head and Stockton Beach.

ving to the short life of prawns (Dakin, 1938; mouth, Lindner, and Anderson, 1933) appro- e management procedures would seem to be ed to ensuring an adequate escapement to sea, gh in view of the great fluctuations dependent rainfall there is little likelihood of the equent catch bearing a direct relationship with mount of spawning stock.

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19

FLOATING SHRIMP TRAPS IN THE DELTAIC AREA OF BURMA

by

U Ba Kyaw*

The Gear

The floating shrimp trap (Fig. 1) is called in Butmese *Pa-zun-phaung*. It is tapering in shape and is made of split bamboo. It has two guiding barriers or wings constructed of bamboo posts or trunks of betel-nut palm and split bamboo screens. Shrimps and other small fishes in a tidal creek are filtered into the trap by the force of the receding tide.

The wing part, known as *Ye-laung*, is about 225 feet long. Its screen walls are as high as the highest water level. The two wings cover nearly the whole width of the creek in the front, but converge gradually to about six feet at the rear end to fit the floating trap called *Hmyon*.

The fore part of the *Hmyon*, called *Ka-la* is open on the top, but the aft portion, known as *Kun-daung*, is closed on all the four sides. The fore end of the trap is about six feet wide and nine feet high, but the rear end is only 14″ in diameter. When set, the fore end touches the creek bottom, but the rear end floats with the catching chamber called *Bon-lon*. The trap can be raised or lowered as desired by means of rollers provided on side-walks.

The *Bon-lon* is a box-like receptacle open on the top. It is constructed of strong timber frames and split bamboo screen. It is 12 feet long, 4½ feet wide and 6 feet high. The chamber is connected with the *Hmyon* by a detachable funnel called *Kun-daung-do*.

The *Kun-daung-do* also is made of split bamboo. It is 3½ feet in length and its fore and aft ends are 18″ and 12″ in diameter, respectively.

A scoop net, about 12″ in diameter, is used for removing the catch from the receptacle.

Labour Employed

If the owner is not an operative, one leader and three or four assistants are employed for the fishing operation, but one or two additional men are needed for drying or smoking part of the catch in the case of the units far away from towns.

Fishing Grounds

The *Pa-zun-phaung* are operated in the tidal creeks connected with flooded rice fields by numerous tiny tributaries in the Irrawaddy Delta. The water is brackish during the dry season, but more or less fresh during the rainy months. The traps are

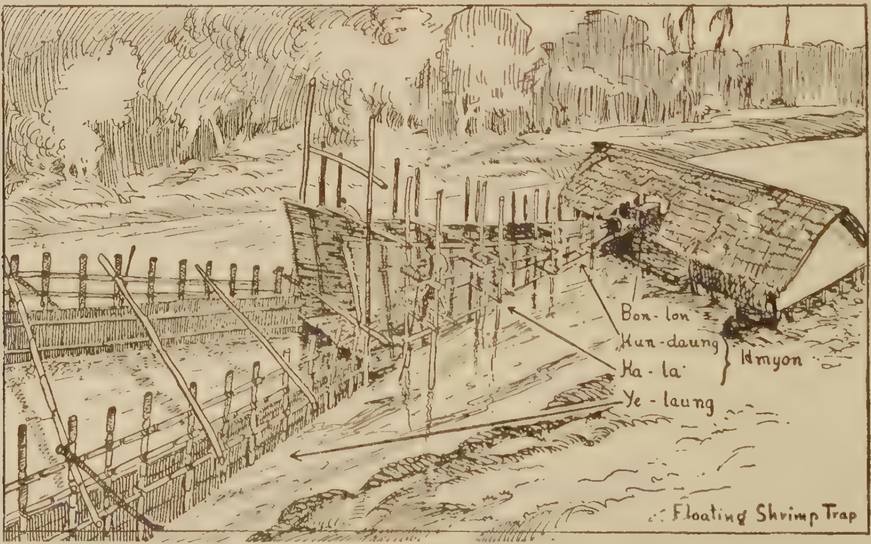

Fig. 1. Floating shrimp trap

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* Executive Officer (Fisheric), Agricultural and Rural Development Corporation, Union Government of Burma, Rangoon.

the lower reaches, above the mouths of these
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Fishing Season

zun-phaung in the upper tidal zone are operated g June to September, but those in the lower ire worked from July to November. The peak for the majority of them is during July and st. Fishing is done only for twelve to fourteen n a month, when the tidal current is strong.

Operation

hermen, first of all, remove the floating debris, y water-hyacinth, collected in the trap and the ber, just before the tide begins to rise. Thereafter, the trap together with the chamber is raised by means of the rollers. The catch is scooped out from the chamber and sorted according to size and species for marketing in fresh form or for smoking and drying. The trap is again set when the tide recedes.

Catch

The catch consists mainly of *Pa-zun-kyawt*, *Metapenaeus* sp., *Pa-zun-dok*, *Palaemon* sp., *Pa-zun-gya*, *Penaeus* sp., small forms of gobies, slipmouths, soles and herring-like fishes. The amount of catch as estimated from a daily average of 60 viss* for each of 58 average catching days for the season, is 3,480 viss.

Prospectus (as of 1953-54)

Capital			
1. Cost of material and construction of the gear, accessories and hut	K**	2,000	0
2. Cost of one boat, about 2 gross-tons	K.	300	0
3. Cost of two kerosene lamps	K.	100	0
4. Cost of material and construction of a drying platform	K.	200	0
5. Cost of 25 baskets	K.	25	0
6. Cost of 2 pans for cooking shrimps	K.	25	0
7. Miscellaneous items	K.	50	0
	K.	2,700	0
) *Operating expenses*			
1. Wages for the season (500+400+3 x 350)	K.	1,950	0
2. Tax	K.	700	0
3. Food for 4 months	K.	1,200	0
4. Firewood for smoking	K.	100	0
5. Depreciation and replacement	K.	1,500	0
6. Interest on loans	K.	300	0
7. Miscellaneous items	K.	50	0
	K.	5,800	0
	K.	8,700	0

(c) *Average sale price of* 3,500 *viss at K.* 2.50

Conclusion

ie dried prawn produced by the *Pa-zun-phaung* is superior in quality to that produced by other or introduced fishing-type units. The retail of the former in Rangoon is Kyats 13.00 per **. The smoked prawn from these traps also is g demand. Practically, there is no problem in preservation and the marketing phases of the stry. It is in the primary phase that most tion is needed. The most important factors nsible for the production are, of course, the ral resource, manpower, finance and equipment. vast network of creeks that drain the fertile, dated rice fields of the delta area should be an st inexhaustible resource for the present size ie industry, 909 units producing 3 million viss 1953-54.

The wages paid, ranging from K. 350 to K. 400 with free food for about four months' employment are rather high. Availability of manpower might present some problems at first when the industry is encouraged to expand. However, as the prospect of the rice trade in the country is not very bright, part of the manpower from the rice cultivation will most probably be available for the industry.

There is little room for improvement of the gear proper, but labour saving devices can still be worked out. The split bamboo screens and the bamboo raft have to be replaced almost entirely every operating season. The use of tar preservative is being planned to reduce the high cost of replacement.

With such ends in view, a project to increase the production by these prawn traps is being prepared.

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1 viss = 1.65 kilogram

** 4.76 Kyats = 1 US Dollar

*** US $ 1.72 per kilo

20

THE VALIDITY OF THE GENERIC NAMES OF PENAEID PRAWNS

by

D. N. F. Hall*

Penaeus Fabricius 1798

In *Opinion* 104 (1928) the generic name *Penaeus* Weber 1795 (Class Crustacea, Order Decapoda) was placed on the Official List of Generic Names in Zoology. Hemming (*Bull. Zool. Nom.* Vol. 6, Pt. 10, 1952) pointed out that the entry of the generic name *Penaeus*, so spelt, made on the Official List was in itself an error, *Penaeus* being a cheironym of *Penaeus* Weber 1795. The name *Peneus* was used first by Weber on page 94 of his *Nomencl. Ent. Syst. Fabr.* (1795). In that work Weber cited three specific names as the names of species regarded as belonging to the nominal genus *Peneus*, but in each case the specific name cited was a *nomen nudum*. It was proposed by Hemming (*op. cit.*) that the generic name *Peneus* is itself therefore a *nomen nudum* having been published (1) without any verbal indication, and (2) without any previously published nominal species referred to it, and in consequence is invalid.

Weber's *Nomencl. Ent. Syst. Fabr.* was but an advance announcement of the system of classification devised by Fabricius. When Fabricius published his *Supplementum Entomologiae Systematicae* (1798) the generic name in question was spelt *Penaeus*. Fabricius provided his genus *Penaeus* with a verbal diagnosis, and in addition referred validly described nominal species to that genus. At that time *Penaeus* was an available generic name, and is therefore the valid name of the genus. Hemming (*op. cit.*) recommended that the International Commission on Zoological Nomenclature should delete from the Official List of Generic Names in Zoology the invalid name *Penaeus* (emend. of *Peneus*) Weber, 1795, and insert the name *Penaeus* Fabricius, 1798. This recommendation was accepted, and embodied in *Direction* 16.

Sicyonia H. Milne-Edwards 1830

Up to 1914 the generic name *Sicyonia* Milne-Edwards was used regularly for the well known genus of penaeid prawn. In 1914, as is well known, Stebbing (*Ann. S. Afr. Mus.* Vol. 15) pointed out that the generic name *Sicyonia* was preoccupied, having been applied to a genus of Lepidoptera by Hübner in 1816 [*Verz. bekannt. Schmett.* (1)], and he proposed for Milne-Edwards' genus the new name *Eusicyonia*. However, Holthuis, 1952, (*Bull. Zool. Nom.* Vol. 6, Pt. 11, pp. 339-341) noted that the earliest synonym of *Sicyonia* Milne-Edwards is *Ruvulus* De Natale 1850, (*Descriz. zool. Plojaria Crost.* Messina. p. 20). The generic name *Ruvulus* was used first by Cocco in 1832 (*Effem. Sci Lett. Sicilia.* Vol. 2. p. 204) but it was published as a *nomem nudum*. De Natale (*loc. cit.*) made clear the synonymy of *Ruvulus*, and *Sicyonia* Milne-Edwards by placing the former name in parentheses behind the latter, and in consequence, were the Règles to be adhered to strictly, *Ruvulus* De Natale, 1850, would be the correct name for the genus in question.

Holthuis (*loc. cit.*) pointed out that the name *Ruvulus* is practically unknown : that the name *Eusicyonia* is invalid, precedence being taken by *Ruvulus*: that the name *Sicyonia* Hübner 1816 is no longer used for the genus of Lepidoptera to which it was applied : that the name *Sicyonia* Milne-Edwards 1830 was adopted universally from 1830 till 1914, and that even after 1914 many carcinologists continued to use it. He proposed therefore that the International Commission on Zoological Nomenclature should use its plenary powers to supress the generic names *Sicyonia* Hübner 1816, and *Ruvulus* De Natale 1850, and validate the generic name *Sicyonia* Milne-Edwards 1830. This proposal was accepted, and embodied in *Opinion* 382.

Parapeneopsis (Wood) Mason, M. S.,) Alcock 1901, and *Xiphopeneus* Smith 1886.

The valid spelling of the two above cited compound generic names, as of all other generic names of penaeid prawn, is that published by he first authors. There has as yet (16 August 1955) been no proposal to the International Commission on Zoological Nomenclature recommending the use of the plenary powers of the Commission to adjust the spelling of *Parapeneopsis* and *Xiphopeneus* to conform to the more barbaric spelling of the root name *Penaeus* Fabr. 1798, although Mr. Francis Hemming, the Secretary to the International Commission on Zoological Nomenclature, with whom the present writer has recently been in communication, is sounding carcinologists on this subject. It is suggested that those who are interested should forward their opinion direct to Mr. Hemming whose full adress is : "F. Hemming Esq., C.M.G., C.B.E., Secretary to the International Commission on Zoological Nomenclature, 28, Park Village East, Regent's Park, London, N.W. 1."

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* Regional Fisheries Research Station, Singapore.